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V1472 Aql: A MOST UNUSUAL ECLIPSER?

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The variable star V1472 Aql (HR 7680, HD 190658) was discovered by HIPPARCOS (ESA, 1997) and classified as a semiregular variable. It will enter the forthcoming Namelist of Variable Stars No. 74. The photometric observations by HIPPARCOS show a rather regular light curve with the range from 6.382 to 6.537 (HIPPARCOS magnitudes) and a period of $100^{\mathrm{d}}.3727039$. With its M2.5III spectral type, the star seems a good candidate to SRA variables.

However, Lucke and Mayor (1982), from 41 CORAVEL and 4 photographic radial velocities, found the star to be a spectroscopic binary with the orbital period equal to $198^{\mathrm{d}}.716$ (approximately twice the presently derived photometric period) and with $a \sin i = (35.39 \pm 0.76) \times 10^6$ km. In the abstract of their paper, they state that "HD 190658 is an M2III giant which could fill its Roche lobe and eventually show eclipses. HD 190658 is also a high velocity star ($V_0 = -112.1$ km s^{-1}) and has the peculiarity of having the shortest period (198 days) of any binary of type MIII".

If we plot the HIPPARCOS magnitudes folded with the spectroscopic period (see Figure 1), we find a reasonable light curve of an eclipsing or ellipsoidal variable star, with continuous brightness variation and a possible indication of different depths of primary and secondary minima. In the "primary" minimum, the scatter of data points is considerable; it may be a hint to a sharper eclipse overlapping ellipsoidal brightness changes. In this minimum, the red giant is in front of an unidentified companion, not revealed in CORAVEL radial velocity observations. If the eclipsing-binary interpretation of the star's brightness variation is correct, this would make the star a quite unusual "β Lyrae" variable. The high-velocity red giant's mass could be rather moderate, and the nature of the companion is not easy to guess. Note that the star is in fact a triple system: HIPPARCOS observations refer to both components of ADS 13344, which, according to the BS catalog (Hoffleit and Jaschek, 1982), is a common-proper-motion pair with $\Delta m = 4^{\mathrm{m}}.0$ and $2''.7$ separation. Additional observations of this peculiar object are needed. Note that the next "primary" minimum is predicted approximately for August 15, 1997.

I acknowledge that, preparing this note, I used the SIMBAD data base. Thanks are due to O.V. Durlevich, S.V. Antipin and M.S. Frolov for assistance and useful discussions.

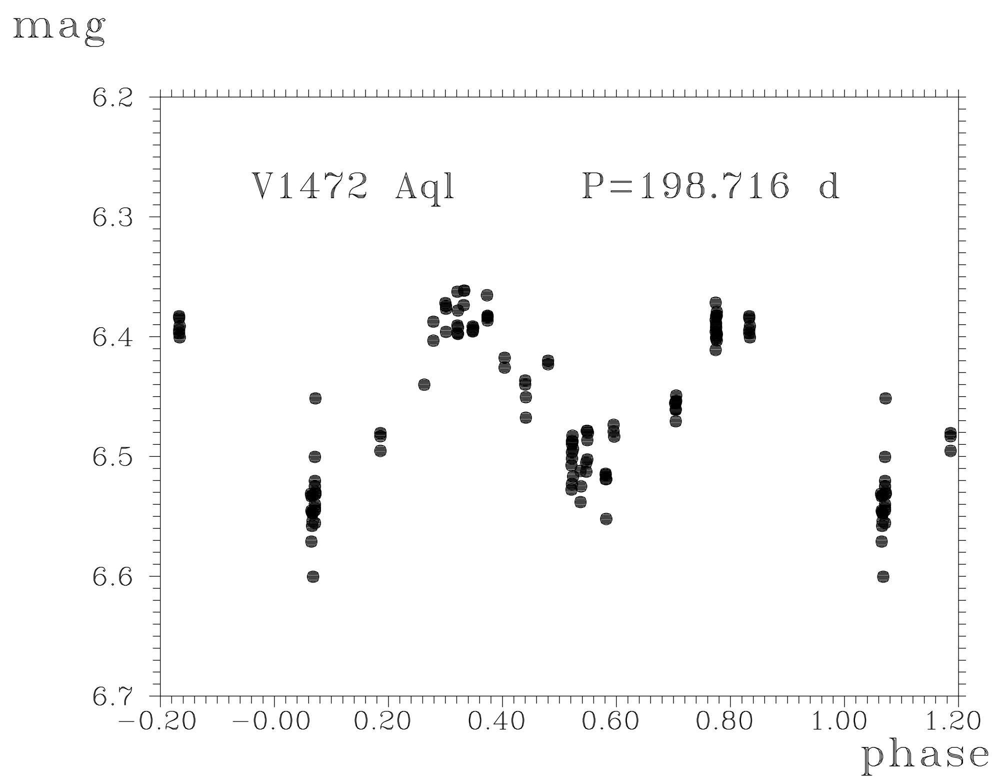

Figure 1. The phased light curve of V1472 Aql from HIPPARCOS photometry and spectroscopic elements of Lucke and Mayor (1982)

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PHOTOMETRIC OBSERVATIONS OF THE PRIMARY MINIMUM OF THE ACTIVE ALGOL BINARY RZ CASSIOPEIAE

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The active Algol binary RZ Cas has been well-known for its irregular period variations and also for the unusual changes of the shape of light curves at the bottom part of the primary minimum. Concerning the period variation, Hegedüs *et al.* (1992) proposed a possibility of the light-time effect and the apsidal motion, but Kiss *et al.* (1995) denied it according to their photometric observations. Narusawa *et al.* (1994) suggested the similarity of activities between the RZ Cas and RS CVn stars. Light changes within the primary minimum normally provides light curves of the partial-eclipse type. However, some observers have reported that occasionally flat bottom (which resembles a total eclipse) appeared at the primary minimum (e.g., Nakamura *et al.* 1991, Hegedüs *et al.* 1992, Narusawa *et al.* 1994 and Dumont 1995). The cause of this phenomenon and its relation to the period variation have not yet been made clear.

Some systematic photometry of RZ Cas was planned and carried out at various places in Japan to monitor its photometric behaviour. Here the results of the observations performed at five places in Japan from January 1995 to December 1996 are reported. The photoelectric photometry with PMT was made at three observatories and the CCD photometry was done at two observatories as listed in Table 1. At all the places the V or R colour filter similar to the standard Johnson-Kron-Cousins system was used. HR 791 was employed as the comparison for the photoelectric observations, which is the same star as was used by Narusawa *et al.* (1994). Two nearby stars, GSC 4317-1437 and GSC 4317-1578, were chosen as the comparison and check stars for the CCD observations, which were previously used by Narusawa & Okyudo (1993).

The estimated moments and the shapes of the light curves of the primary minima are given in Table 2. The E and O−C values were calculated from the following ephemeris in Narusawa *et al.* (1994).

$$Min I = HJD\,2448960.2122 + 1\overset{d}{.}1952572 \times E \qquad (1)$$

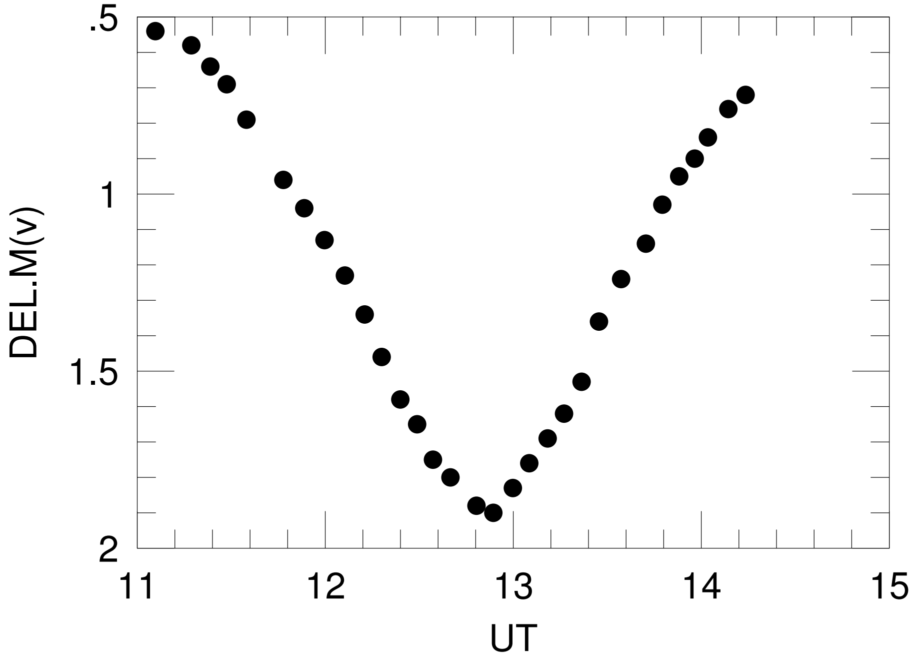

Figure 1. Light curve at the primary minimum of 21 Oct. 1995 (HJD 2450012) observed by Nagai

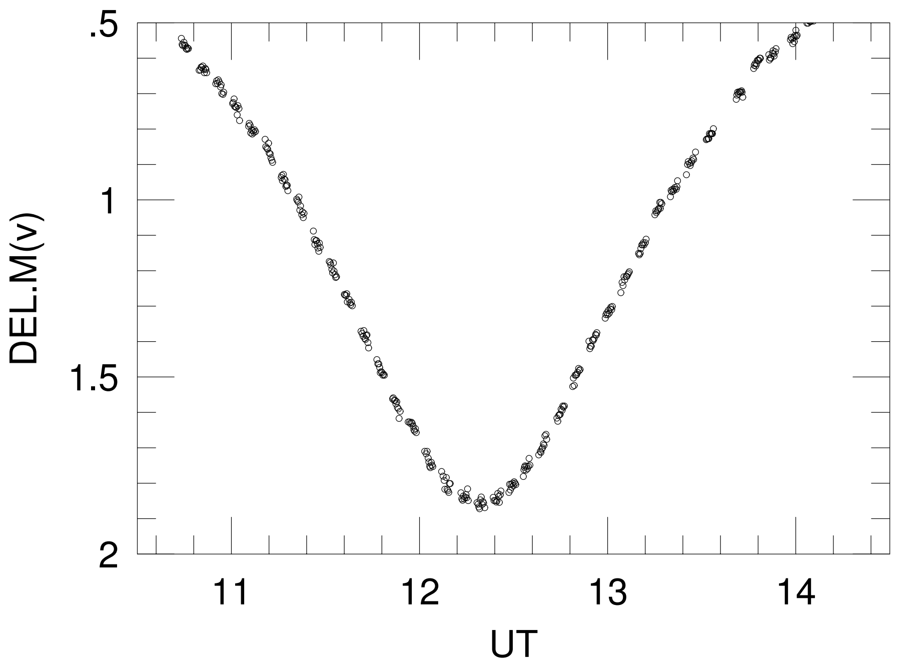

Figure 2. Light curve at the primary minimum of 27 Oct. 1995 (HJD 2450018) observed by Arai

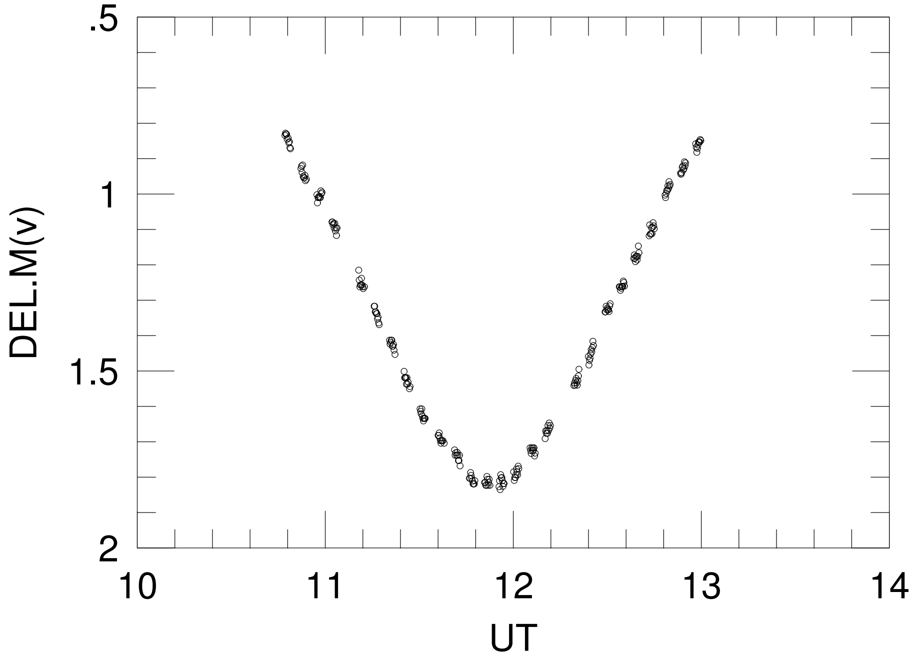

Figure 3. Light curve at the primary minimum of 21 Dec. 1995 (HJD 2450073) observed by Arai

Table 1: Observational instruments

Observer	Telescope(I)	Camera/Detector
Ohmori	40cm Cs†	PMT (Hamamatsu 1P21)
Arai	28cm SC	PMT (Hamamatsu R1414)
Fujii	28cm SC	CCD (SBIG ST6)
Nagai	20cm SC	PMT (Hamamatsu R647-04)
Yasuda	60cm Cs*	CCD (SBIG ST6)

(I) Cs:Cassegrain reflector, SC:Schmidt Cassegrain telescope
†:Science Museum of Kawasaki City
*:Nishi-Harima Astronomical Observatory

A probable orbital-period change occurred during the period HJD 2448220 and HJD 2448581 (Narusawa *et al.* 1994). The ephemeris (1) was derived with the observed times after HJD 2448581. The O−C values in Table 2 indicate no apparent period change and the orbital period has been surely constant from HJD 2448581 to HJD 2450446 (about 5 years).

Some of the observed light curves are shown in Figures 1-3. As seen in Table 2, we did not observe the flat bottom in the primary minimum during our observations. It is necessary to continue the photometric observations to clarify the relation between period changes and light curve variations.

Table 2: Estimated times and shapes of the observed primary minima

HJD 2400000+	E(I)	O−C(I) (day)	Filter	Shape(II)	Observer
49723.9824	639	+0.0008	V	P	Arai
49723.983	639	+0.001	V	−	Ohmori
49743.106	655	+0.000	V	−	Ohmori
49988.136	860	+0.003	V	−	Yasuda
49994.1123	865	+0.0026	R	P	Fujii
50012.0401	880	+0.0016	V	P	Nagai
50018.0157	885	+0.0009	V	P	Arai
50023.9920	890	+0.0009	V	P	Arai
50023.9931	890	+0.0020	R	−	Fujii
50031.1652	896	+0.0025	R	−	Fujii
50072.9967	931	+0.0000	V	−	Arai
50078.9728	936	−0.0001	V	P	Arai
50445.921	1243	+0.004	V	−	Nagai

(I) The E and O−C values are calculated from the ephemeris (1)
(II) P:Partial, −:Uncertain

We would like to acknowledge Dr. Y. Nakamura at Fukushima University for useful comments. We are also grateful to Mr. H. Akazawa, Mr. Y. Ito, Mr. N. Ohkura and Mr. E. Suzuki who helped this work. This investigation was supported in part by a Science Research Grant (B) No. 08914028 from the Ministry of Education, Science, Sports and Culture of Japan.

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PHOTOMETRY OF THE ECLIPSING BINARY V1481 Cyg IN THE OPEN CLUSTER NGC 7128

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The variability of V1481 Cyg (= HBV472; m=12.1 — 12.6pg; Sp:B2V) was discovered by Kohoutek (1972). The star lies in the center of the very compact ($D = 3\farcm2$) young open cluster NGC 7128. There are only photographic (B,V,R) observations of the variable made by Alksnis (1973). He determined the period of V1481 Cyg and it was classified as an EB type eclipsing binary. The ephemeris for minima is:

$$Min I = JD2440040.61 + 2\overset{d}{.}7634 \times E$$

Our UBVR photoelectric observations of the binary were carried out with 1m and 0.6m telescopes at Mt.Maidanak Observatory (Uzbekistan) in 1993–1995. The star No. 2 of Hoag et al. (1961) catalogue was chosen as a comparison one ($V = 10\overset{m}{.}13$, $U-B = 0\overset{m}{.}24$, $B-V = 0\overset{m}{.}36$, $V-R = 0\overset{m}{.}28$). Total number of the measurements are 126 in U, 170 in B, 220 in V and 172 in R. In accordance with our estimation the probable error of a single observation of V1481 Cyg is $0\overset{m}{.}05$ in U, $0\overset{m}{.}013$ in B, $0\overset{m}{.}008$ in V, $0\overset{m}{.}009$ in R.

Having used all times of brightness weakening we improved the ephemeris of the binary by the method of least squares, as follows:

$$\begin{array}{rcl} Min I = JDH2440040.707 & + & 2\overset{d}{.}763252 \times E \\ \pm\ 0.015 & \pm & 0.000007 \end{array}$$

This ephemeris was used to calculate the O−C residuals in Table 1.

Table 1

Observers	*JDH24...*	*E*	*O − C*
Alksnis, Začs (1981)	40731.470	250	$-0\overset{d}{.}050$
	40944.300	327	+0.009
Kohoutek (1972)	41151.489	402	−0.045
	41187.487	415	+0.030
Alksnis, Začs (1981)	41259.293	441	−0.008
	41596.452	563	+0.034
	41911.465	677	+0.036
Present paper	49170.442	3304	−0.049
	49173.266	3305	+0.011
	49579.447	3452	−0.006
	49582.246	3453	+0.030

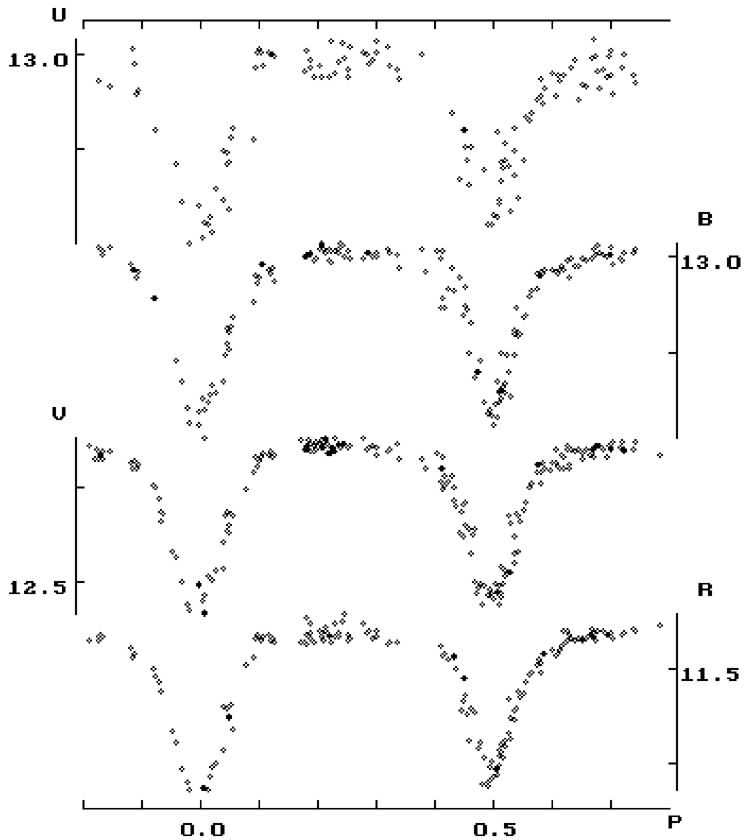

Figure 1.

The U, B, V, R light curves are shown in Figure 1. Their mean characteristics are listed in Table 2.

Table 2

Phase	V	$U-B$	$B-V$	$V-R$
Max	12.14	0.11	0.86	0.73
MinI	12.55	0.07	0.89	0.74
MinII	12.54	0.04	0.89	0.75

References:

Alksnis, A., 1973, *Astron. Tsir.*, No. 761, p.7
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Hoag, A.A. *et al.*, 1961, *Publ. Naval. Obs.*, XVII, Part VII, 439
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OBSERVATIONS OF THE GSC 3505_677 FIELD

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We observed the field containing one of the objects, (16548-39) = GSC 3505_497, found in a survey by Beers et al. (1994I, who concluded from objective prism spectral observations that it was "a medium faint star displaying moderate to strong CaII H&K and Balmer emission".

The automated 0.5-m telescope, Cousins V, R and I filters and CCD camera of the Climenhaga Observatory of the University of Victoria (Robb and Honkanen, 1992) were used to make photometric observations of the stars. Using IRAF[1] routines, the frames were de-biased and flat-fielded, and the magnitudes were found from 6 arc second aperture photometry using the Gaussian centering option of the PHOT package.

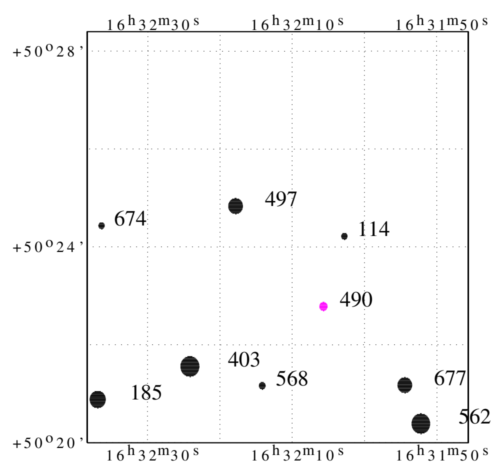

Figure 1. Finder chart of the field labeled with the GSC numbers (Jenkner et al., 1990)

The field of stars is shown in Figure 1 and their designations, coordinates (J2000) and magnitudes from the Hubble Space Telescope Guide Star Catalog (GSC) (Jenkner et al., 1990) and the measured ΔR magnitudes are tabulated in Table 1. The ΔR differences in magnitude are found from our data in the sense of the star minus GSC 3505_403. To look for brightness variations during a night the standard deviation of the differential

[1] IRAF is distributed by National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract to the National Science Foundation

Table 1: Stars observed in the field of GSC 3505_677

GSC No.	RA J2000.	Dec. J2000.	GSC Mag.	ΔR Mag.	V	V−R$_C$	R−I$_C$
3505_497	$16^h32^m18^s$	$+50°24'50''$	13.3	$+1.080 \pm .006$	13.24	0.36	0.38
3505_403	$16^h32^m24^s$	$+50°21'33''$	12.2	–	12.10	0.30	0.29
3505_185	$16^h32^m37^s$	$+50°20'53''$	12.9	$+0.825 \pm .006$	12.95	0.31	0.35
3505_677	$16^h31^m54^s$	$+50°21'10''$	13.3	$+1.368 \pm .083$	13.52	0.59	0.37
3505_562	$16^h31^m52^s$	$+50°20'23''$	12.2	$+0.097 \pm .007$	12.44	0.55	0.33

Table 2: Heliocentric Julian Dates of minimum light 2450000+

R Filter		R filter		I Filter	
HJD	O−C	HJD	O−C	HJD	O−C
624.7432	.0001	634.7865	.0005	649.8529	.0024
627.8118	.0001	634.9254	−.0001	650.8259	−.0010
632.8325	−.0007	648.7342	−.0005		
633.8095	−.0001	648.8733	−.0008		
633.9494	.0003				

magnitudes for each star during a night was calculated and ranged from $0^m_.005$ for bright stars on a good night to $0^m_.030$ for the faint stars on poor nights. To measure night to night variations a run mean of the eight nightly averages was calculated and is shown as ΔR in Table 1. While the object of our initial interest, GSC 3505_497, proved constant, GSC 3505_677 is a significantly variable star. Due to the small field of view extinction effects were negligible and no corrections have been made for them. No corrections have been made to transform the ΔR magnitude to a standard system. Brightness variations in GSC 3505_677 were evident during each night. A least squares fit of a single sine wave to all the the data shows a deep minimum in χ^2 at an inverse period of $7.17d^{-1}$, but a plot of the light curve shows unequal minima which led us to double the period. By the method of Kwee and van Woerden (1956) eleven heliocentric Julian times of minima were found and are tabulated in Table 2. A fit to these times gives the ephemeris:

$$\text{HJD of Minima} = 2450624^d_.7430(5) + 0^d_.27897(2) \times \text{E}.$$

where the uncertainties in the final digit are given in brackets. The differences of the times of minima and the ephemeris are the O−C values given in Table 2.

A plot of the differential (GSC 3505_677−GSC 3505_403) R magnitudes phased at this period is shown in Figure 2 with different symbols for each of the nights. I band data, observed on three nights, shows the same light curve shape. Forty normal points were formed from the R and the I light curve and then the color R−I was found from the normals. The maxima were approximately 0.01 redder than the minima, indicating very little temperature difference across the star and between stars.

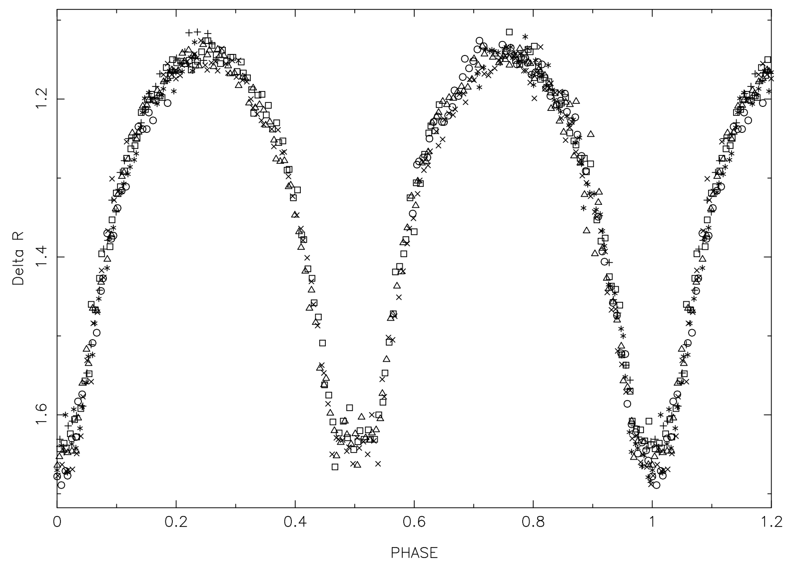

Figure 2. R band light curve of GSC 3505_677 for 1997

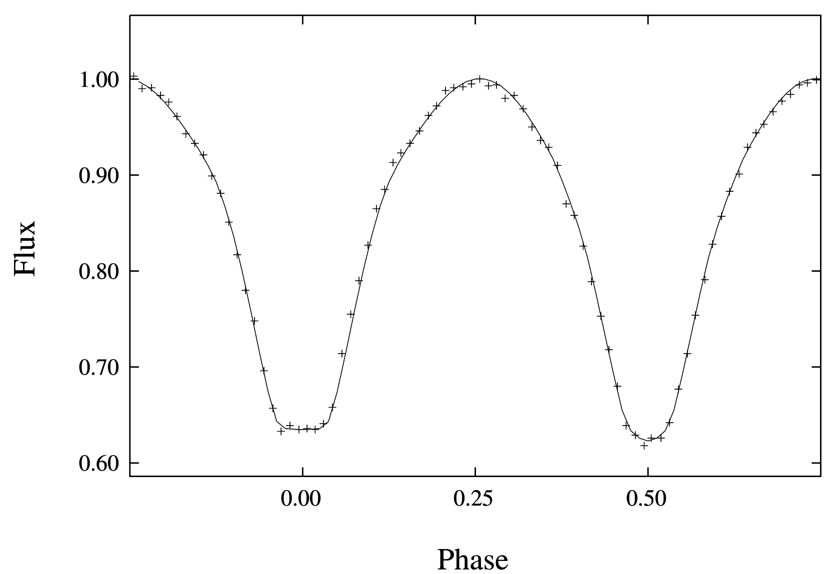

Figure 3. R band light curve (points) with example model (line) of the contact system

To help classify the variable star V, R and I frames were obtained under photometric conditions along with observations of four nearby bright standard stars (Moffett and Barnes, 1979). The V band brightness, $(V-R)_C$, and $(R-I)_C$ colors are listed in Table 1 for the brightest stars in our field. However great caution should be exercised in using these data since they are derived from only a few standard stars and the colors were transformed from the Johnson system to the Cousins system using the equations of (Taylor, 1986). This period and $(V-I)_C$ agree very well with the short-period/blue envelope relation given by Rucinski (1997) for W UMa systems.

While certainly not definitive these colors confirm that GSC 3505_677 is a late type (approximately K1V) star (Cousins 1981). A dwarf star of this color would be expected to have an absolute magnitude of approximately V=6.2 (Allen 1976), so from our apparent magnitude of 13.52±.08 at maximum brightness, we find the distance to be about 300±100 parsecs. Using the period, $(V-I)$, relation for absolute I magnitude for contact systems (Rucinski 1997), the distance can be found to be 400 ± 60 parsecs.

From the color information and the shape of the light curve we can surmise that the primary star and the secondary star is a contact system. To make an example model light curve using Binmaker 2.0 (Bradstreet 1993), the phases of the points have been increased half a cycle and the temperature of the large star was assumed from the $(R-I)C$ to be 4750K. The data are best fitted with an inclination of 85°, a mass ratio of 3.45 and a fill out factor of 0.1. The temperature of the small star was adjusted to 4820 K to get the excellent fit seen in Figure 3. The mass ratio and fill-out factor are correlated such that an increase in the mass ratio of about 0.2 can be compensated by an increase in the

fill out factor by 0.1 to get nearly as good a fit. The relative sizes and shapes of the components of the system are shown in Figure 4, again using Binmaker 2.0.

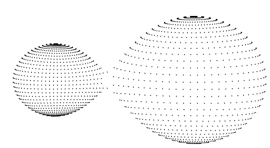

Figure 4. Three-dimensional model of the contact system at phase 0.25

The star GSC 3505 677 is therefore a W UMa system with late type components. Further photometric observations will be valuable to look for period changes due to mass transfer and to observe precise colors and thus determine the temperature of the stars. Spectroscopic observations will be important to get a good spectral class for the system and radial velocities will measure the scale of the system and the masses. RG would like to thank the Austrian Ministry of Science for financial support.

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NEW VARIABLES IN THE FIELDS OF V1413 AQUILAE AND AU HERCULIS

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During the observation and data analysis of the variable stars V1413 Aquilae and AU Herculis, previously unknown possible variables were found in each field. We used Pickles and the Guide Star Catalog to obtain the positions of the new variables; the coordinates of the possible new variable (Guide Star Catalog #1585 1087) in the V1413 Aquilae field are $\alpha_{2000} = 19^{\rm h}03^{\rm m}46^{\rm s}$, $\delta_{2000} = 16^\circ 29' 52''$. The coordinates of the possibly varying star (Guide Star Catalog #2102 1349) in the AU Herculis field are $\alpha_{2000} = 17^{\rm h}56^{\rm m}59\overset{\rm s}{.}6$, $\delta_{2000} = 29^\circ 47' 14\overset{''}{.}8$. Neither star is listed as a suspected or known variable in the New Catalogue of Suspected Variable Stars (Kholopov *et al.*, 1982), SIMBAD, or any issues of the Information Bulletin on Variable Stars from 1993 to the present, including the 72nd Name-List of Variable Stars (IBVS No. 4140, 1995). Thus, we conclude the stars have not previously been noted as variables.

All observations of both new variables were made with a Photometrics CCD camera attached to the Wellesley College 0.6 meter Cassegrain Reflecting telescope. AU Herculis has been observed and analyzed since the summer of 1993, and V1413 Aquilae has been observed since the summer of 1994. It was noticed during the analysis of both stars that one of the comparison stars in each of the fields was showing a larger variation of magnitude than the other comparison stars.

The new variable in the AU Herculis field varies by approximately 0.5 magnitudes in both the R and the V filters. This is compared to the significantly smaller variation of approximately 0.09 and 0.07 magnitudes shown by the other comparison stars in the R and V filters. The new variable in the field of V1413 Aquilae varies in magnitude by approximately 0.3 magnitudes in the I filter, 0.4 magnitudes in the R filter, and 0.5 magnitudes in the V filter. The other comparison stars in this field vary by approximately 0.07 in the I filter, 0.15 in the R filter, and 0.09 in the V filter. Figures 1 and 2 show the variations of the star in the field of AU Herculis in the V filter and. the variation of the star in the V1413 Aquilae field in the I filter respectively. Figures 3 and 4 identify the new variable stars. For each image, north is up and the field is about nine arcminutes square.

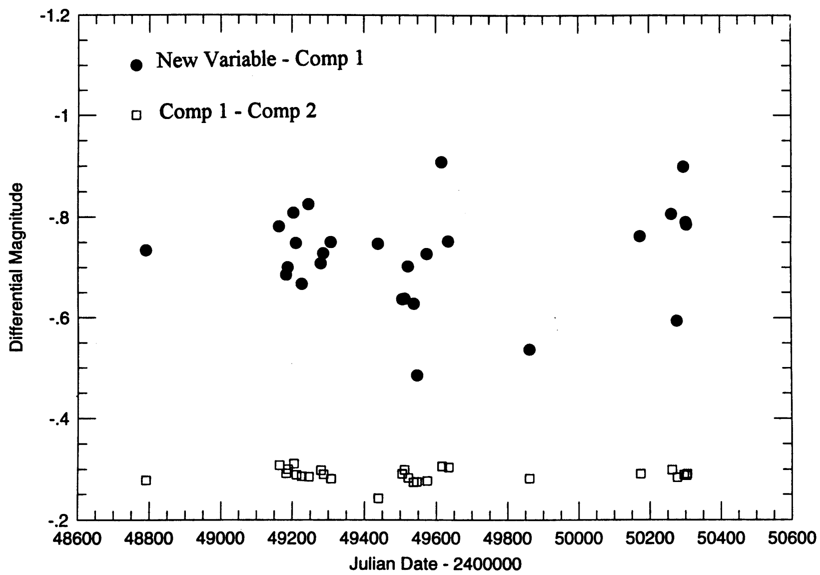

Figure 1. V Light Curve of the New Variable in the AU Herculis field

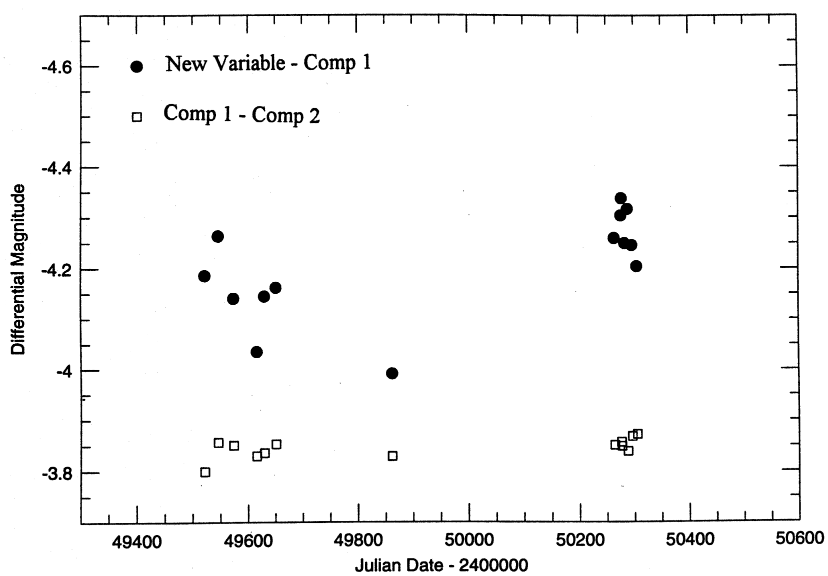

Figure 2. I Light Curve of a New Variable in the V1413 Aquilae field

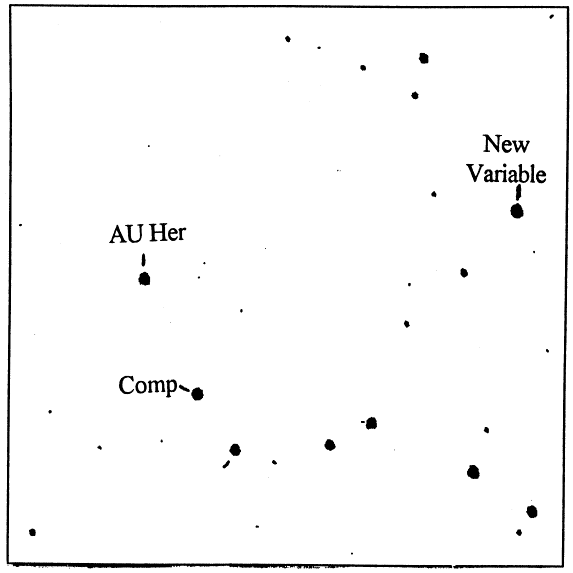

Figure 3. A finder chart for the new suspected variable star in the field of AU Herculis

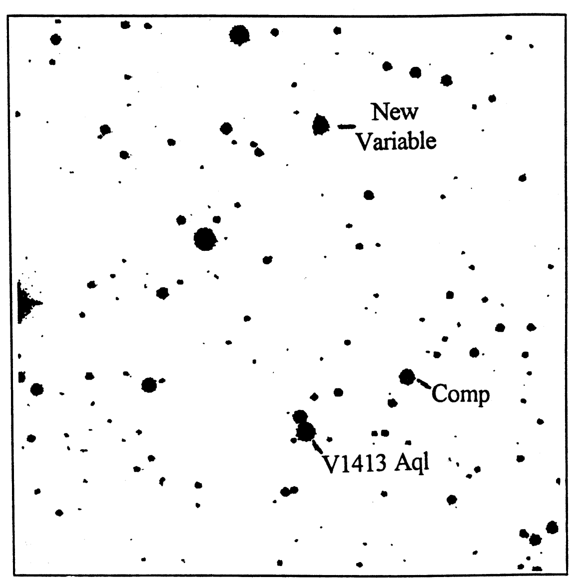

Figure 4. A finder chart for the new suspected variable star in the field of V1419 Aquilae

The two new variables were examined for periodicity using a Fourier transform period fitting program written by Charles Prosser of the Harvard Center for Astrophysics. No likely periods were found between 0.2 and 400 days.

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A NEW PECULIAR Be OBJECT MWC 657

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MWC 657 was distinguished as a star of B spectral type with $m_V = 12^m$ and H_α in emission (Merill & Burwell 1943). Dong & Hu (1991) identified it with an IRAS source 22407 + 6008 by coincidence of the optical and infrared (IR) positions (R.A. $22^{\rm h}40^{\rm m}47\overset{\rm s}{.}6$, *Dec.* $+60°08'17''$, 1950.0). There is an object of $V = 12\overset{\rm m}{.}5$ at this position in the Guide Star Catalog (GSC 4265.0873). No optical and near–IR photoelectric observations or detailed spectroscopy have been reported previously for the object. IR–fluxes from the object measured by the IRAS and obtained by us using the ADDSCAN procedure are 5.93, 4.22, and 0.40 Jy at 12, 25, and 60 μm respectively. This means that MWC 657 has an extremely red spectral energy distribution (SED) similar to those of the objects surrounded by circumstellar dusty envelopes.

We obtained photoelectric $UBVRIK$ observations of MWC 657 in the Johnson system at a 1–meter telescope of the Tien–Shan Observatory (Kazakhstan) equipped with a two–channel photometer–polarimeter of the Pulkovo Observatory (Bergner et al. 1988) in September and December 1996 (Table 1). Typical errors are $0\overset{\rm m}{.}05$ in the U–band, $0\overset{\rm m}{.}03$ in the $BVRI$–bands, and $0\overset{\rm m}{.}15$ in the K–band. HD 214764 (F0) was used as a comparison star and HD 211589 as a check star (Kornilov et al. 1991). Brightness of the latter was found to be constant with respect to the comparison star with an accuracy of $0\overset{\rm m}{.}01$.

The photometric results lead us to the following qualitative conclusions:

1. The star is heavily reddened. Its $U-B$ and $B-V$ colors locate at a reddening line for early–B stars.
2. A local peak in the SED corresponding to the R–band (see Fig.1) points out on a strong emission in $H\alpha$ which is consistent with the Merrill & Burwell's (1943) description.
3. Brightness in the K–band and the IRAS colors imply presence of the infrared excess which can be explained by circumstellar dust radiation. A steep decrease of the observed flux towards longer wavelengths shows that the dusty envelope should be optically thin in the optical region and have quite a small radial extension.

Table 1: Photometry of MWC 657

JD2450000+	V	$U-B$	$B-V$	$V-R$	$V-I$	K
349.25	12.85	−0.2:	1.35	1.75	2.73	
353.29	12.57	0.01	1.32	1.51	2.47	
417.11	12.70	−0.27	1.40	1.50	2.43	
420.08	12.62	0.00	1.39	1.55	2.42	
422.06	12.57	0.03	1.49	1.55	2.46	6.67
424.10	12.63	−0.11	1.48	1.49	2.47	
427.09	12.67	−0.12	1.49	1.53	2.47	6.31
429.09	12.68	0.02	1.39	1.55	2.31	
433.11	12.62	−0.05	1.44	1.52	2.41	
439.13	12.63	−0.36	1.80	1.50	2.25	

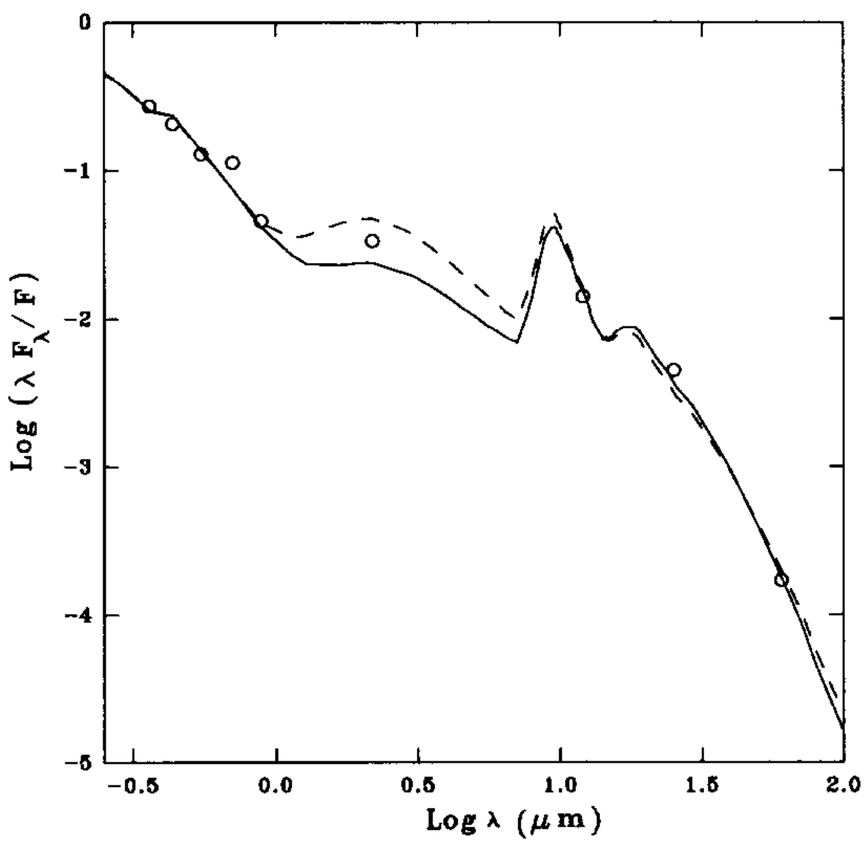

Figure 1. Spectral energy distribution of MWC 657 (circles) and the modeling results. The model with α=1.5 is shown by solid line, with α=2.0 by dashed line. Other parameters are described in text. The SED is expressed in units of the bolometric flux (F).

Taking into consideration these items we tried to model the SED of MWC 657 constructed from averaged photoelectric data and the IRAS photometry using a radiative transfer code DUSTY by Ivezić, Nenkova, & Elitzur (1997) for spherical dusty envelopes. The dust temperature distribution is calculated self–consistently including dust scattering, absoprtion, and emission. We used the Kurucz (1979) models to describe radiation of the central star and optical properties of the interstellar dust (Mathis, Rumpl, & Nordsieck 1977) for the dust particles in the envelope. The dust sublimation temperature was fixed at 1500 K. A grid of models with different stellar temperatures (T_*), the dust density distributions ($\propto r^{-\alpha}$, where r is the distance from the star), the envelope optical depths (τ_V), and ratios of its outer and inner radii (Y_{out}) has been calculated. An additional free parameter of the fitting was interstellar extinction (A_V).

The modeling showed that the SED in the IR region could be fitted well with different parameters of the envelope while T_* and A_V defining the SED in the optical regime remained the same: 20000 K and $4\overset{\mathrm{m}}{.}9$ respectively (Fig.1). The best fit was found for α between 1.5 and 2.0. Other envelope parameters are different at these boundaries: τ_V = 0.03, Y_{out} = 100 for α =1.5 and τ_V = 0.05, Y_{out} = 700 for α =2.0. The former density law is expected for free–fall matter while the other one for constant mass loss from the central object.

The bolometric flux calculated (F_{bol}) from the theoretical SED scaled with the dereddened observations is 1.2×10^{-4} Wm^{-2}. Since stellar radiation dominates in the optical region and scattering is negligible, one can estimate the star's angular diameter or ratio of its radius (R_*) to distance (D) towards the object using a formula $F_{bol} = \sigma T_*^4 (\frac{R_*}{D})^2$. This value turned out to be 1.2×10^{-10} which corresponds to $R_* = 5.9 R\odot D_{kpc}$. Interstellar extinction in the object's direction smoothly increases with distance from the Sun up to 3–4^m at D of about 2–3 kpc with almost no further increase beyond this region (Bergner et al. 1986). Thus, even if we take 2 kpc as a distance toward the star it will have a bolometric luminosity $\log \frac{L_{bol}}{L\odot} = 3.67$ and locate above the main sequence.

Some suggestions on the object's evolutionary state can be presented. Usually such optically and geometrically thin envelopes are not observed in pre–main–sequence objects. However, there are several peculiar B–type stars with a similar far–IR brightness decrease which have been suspected as possible Herbig Ae/Be stars (HD 45677, HD 50138). Other interpretations cannot be excluded, i.e. a binary system or a very young planetary nebula, but they require additional observational evidences. It is certainly needed further study of this interesting object. This should include at least optical spectroscopy, near–IR photometry, and optical photometric monitoring.

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HD 213637 IS A RAPIDLY OSCILLATING Ap STAR

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The rapidly oscillating Ap (roAp) stars are cool, magnetic, chemically peculiar A-type stars that pulsate with periods in the range 6–16 minutes and Johnson B semi-amplitudes ≤ 0.008 mag. The observed characteristics of the roAp phenomenon have been reviewed by Martinez and Kurtz (1995) for the 28 confirmed roAp stars known at the time of that writing. This Bulletin announces the discovery of the 29th roAp star, HD 213637.

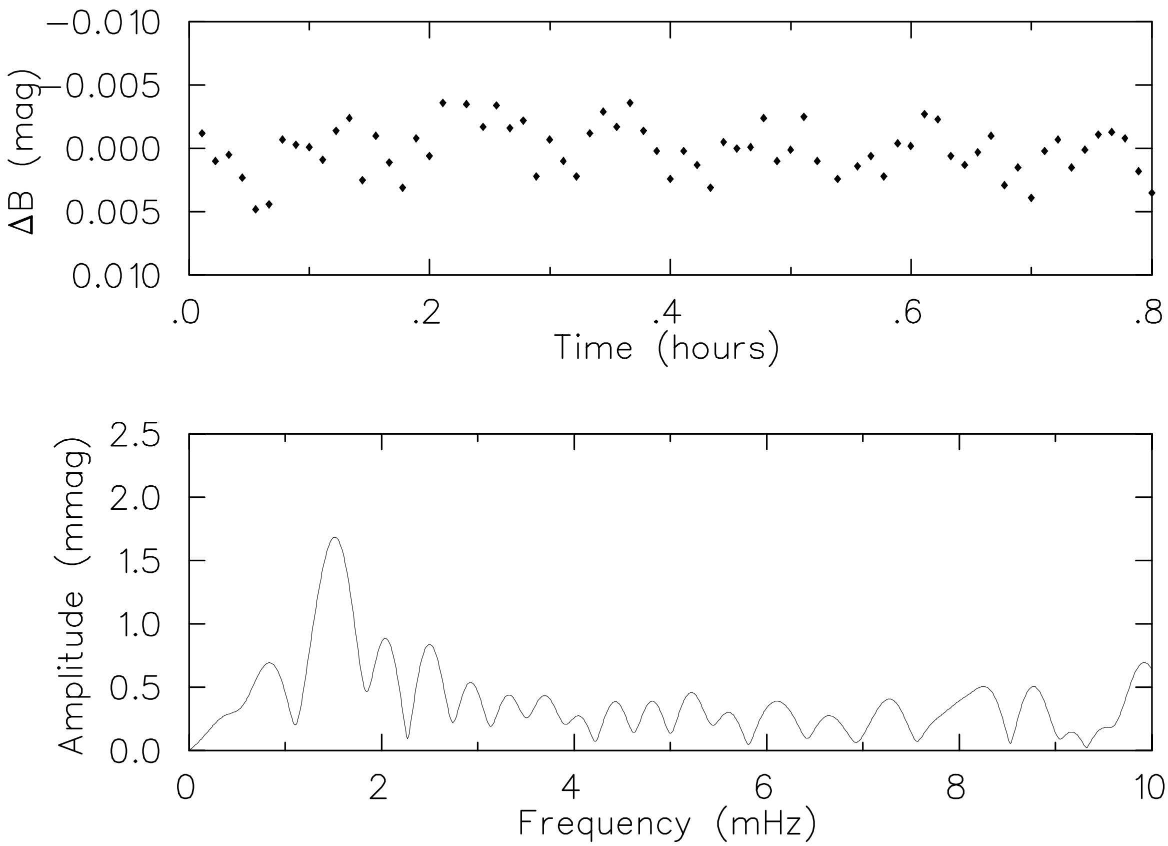

Figure 1.

HD 213637 is classified by Houk & Smith-Moore (1988) as A(p EuSrCr). Martinez (1993) determined its Strömgren indices to be V=9.611, $b-y = 0.298$, $m_1 = 0.206$, $c_1 = 0.411$ and $\beta = 2.670$. Our attention was particularly drawn to the calculated metallicity and luminosity indices, $\delta m_1 = -0.035$ and $\delta c_1 = -0.031$, both of which indicate strong metallicity and line blocking in the v band. As these are characteristics that we associate with the roAp stars, we decided to search for rapid oscillations in HD 213637. Our observations comprised continuous 10-s integrations in Johnson B light acquired with the Radcliffe Peoples Photometer attached to the 0.75-m telescope of the South African Astronomical Observatory at Sutherland.

Rapid oscillations were discovered in HD 213637 on the night of 26/27 July 1997, JD 2450656. Fig. 1 shows the discovery light curve (top) and its amplitude spectrum (bottom). The data shown here have been corrected for coincidence counting losses, sky background and extinction, and were then binned to 40-s integrations. The oscillations, which are barely discernible in the light curve, are more evident in the Fourier representation of the data in the lower panel. The amplitude spectrum peaks strongly at a frequency of 1520±220 μHz, corresponding to a pulsation period of 11 minutes. Subsequent to the discovery of these pulsations a number of additional confirmatory light curves were acquired. Inspection of the available light curves indicates the presence of amplitude modulation, which may be caused by beating among several frequencies and/or non-radial pulsations being seen from variable aspect as the star rotates. Further observations and an analysis of those observations will be presented in a future publication.

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A NEW POSITION AND PERIOD FOR CY DRACONIS

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CY Draconis is a suspected RR Lyrae star that is listed without a period in the *General Catalog of Variable Stars* (GCVS). We found no reference to CY Draconis in the Simbad database. We observed CY Draconis from 01 July 1997 to 30 July 1997 on the 24-inch telescope at Wellesley College. A few images were taken each night in each of the I, R, and V filters. The first part of the summer a PM512 CCD camera was used, but this was upgraded on 23 July 1997 to a Tektronics CCD with a 1024×1024 chip. We did photometry on CY Draconis and several comparison stars in the field using IRAF. The differences in the magnitudes of the comparison stars and CY Draconis were plotted in a spreadsheet. We made a phase diagram to try to determine the period of the star and found it to be about 0.53515 days. The V filter amplitude is about 0.7 magnitudes. The data we collected confirms that CY Draconis is an RR Lyrae star and seems to place it in the RRab group. We illustrate the V folded light curve in Figure 1.

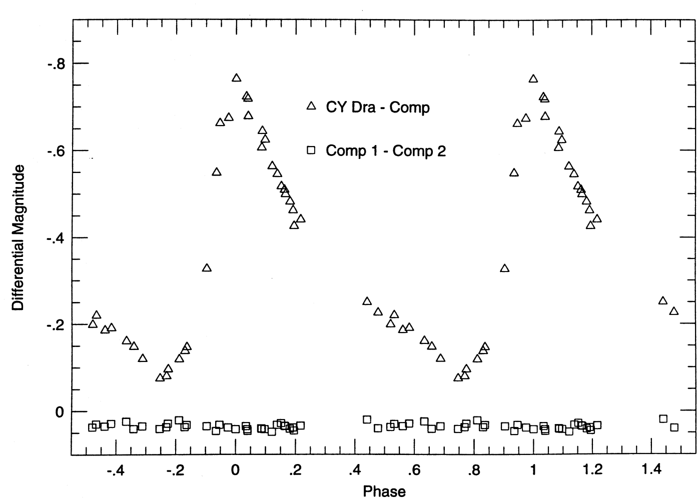

Figure 1. The V folded light curve for CY Draconis assuming a period of 0.53515 days

While studying this star, we found that the coordinates given under the GCVS's listing of CY Draconis are off by almost one arc minute. Using the *Guide Star Catalog*, we determined more precise coordinates for CY Draconis are $\alpha_{2000} = 19^{\rm h}46^{\rm m}06^{\rm s}$, $\delta_{2000} = 59°34'29''$. Figure 2 gives a finder chart of CY Draconis identifying the comparison star we used.

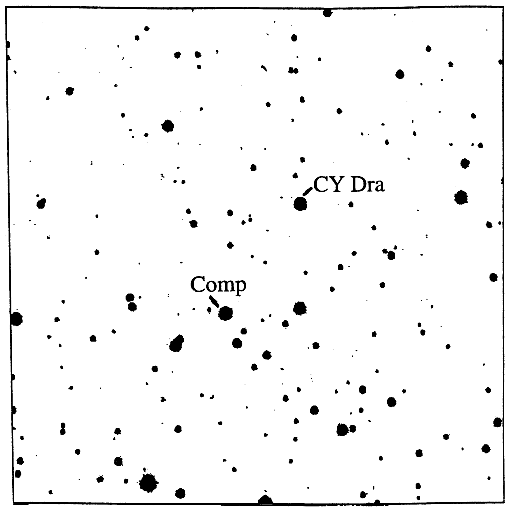

Figure 2. Finder chart for CY Draconis identifying the comparison star used. North is up. The field of view is approximately 7.5 arcminutes square.

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BVRI OBSERVATIONS OF AN ECLIPSE OF RZ Cas

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The Algol-type eclipsing binary RZ Cas is an interesting system that has both x-ray (McCluskey and Kondo 1984) and radio (Drake *et al.* 1986) emission. The variable is bright (V_{max} = 6.2) with a relatively short period ($1\overset{d}{.}195$) and deep primary eclipse ($\Delta V = 1\overset{m}{.}5$) and therefore has often been observed photometrically. Nevertheless, the system is still not well understood. Particularly puzzling is the change in shape of light curve at primary minimum. It is accepted that the eclipses are partial (Hegedüs *et al.* 1991, Maxted *et al.* 1994, Narusawa *et al.* 1994), but some primary minima exhibit a flat-bottom light curve characteristic of a total eclipse. Recently published examples can be found in Arganbright *et al.* (1988), Hegedüs (1989), Nakamura *et al.* (1991), and Narusawa *et al.* (1994).

Continued minimum timings and photometric monitoring at a variety of wavelengths are needed to determine the cause of the light curve variations. This note presents BVRI observations of a recent primary eclipse. The data were obtained with the 40-cm Cassegrain reflector of the Brooks Astronomical Observatory at Central Michigan University employing a Photometrics Star-1 CCD camera and standard Johnson-Cousins BVRI filters. Details concerning our CCD system, observing techniques, and data reduction methods have been given by Miller and Osborn (1996).

Observations began with clear skies about one hour before the predicted time of minimum on 1996 December 12. Sets of exposures with the four filters were made, alternating between the comparison star HD 15784 = BD+67°224 and RZ Cas. Occasional observations were made of HD 16769 = BD+67°215 as a check star. Clouds appeared shortly after the eclipse minimum and affected the measures until the monitoring ended some 40 minutes later. The exposure times for each filter were kept constant throughout the observations.

Instrumental magnitudes were obtained by aperture photometry of the individual CCD frames. Bias and flat field corrections were applied and then the star brightness measured using a circular aperture of 15" radius and a sky annulus with radii of 19" and 29". The derived values were used to form differential magnitudes with respect to the comparison star. The results are given Table 1, where the time is the fractional heliocentric Julian date after 2450425.0 and colons indicate observations in the presence of clouds. Some measures obviously degraded by clouds have been discarded. The measures of the check star indicate that the magnitudes have mean errors of about 0.02 in B, 0.015 in V and less than 0.010 in R and I.

Table 1: Differential magnitudes relative to HD 15784.
The integer part of the J.D. is 2450 425

Star	Time	ΔB	Time	ΔV	Time	ΔR	Time	ΔI
RZ Cas	.....	.....	.5564	0.271	.5584	0.433	.5592	0.534
	.5649	0.263	.5654	0.469	.5666	0.611	.5669	0.677
	.....	.....	.....	.....	.5704	0.703	.5707	0.763
	.5740	0.512	.5745	0.687	.5751	0.813	.5763	0.858
	.5793	0.659	.5799	0.844	.5802	0.937	.5805	0.950
	.5808	0.726	.5813	0.888	.5818	0.973	.5821	0.981
	.5862	0.864	.5867	1.024	.5872	1.080	.5875	1.076
	.5879	0.913	.5884	1.057	.5889	1.113	.5894	1.096
	.5921	0.969	.5927	1.103	.5933	1.172	.5936	1.148
	.5940	1.008	.5948	1.139	.5955	1.192	.5958	1.162
	.5964	1.044	.5970	1.175	.5975	1.226	.5977	1.188
	.6003	1.082	.6007	1.185	.6013	1.236	.6018	1.185
	.6021	1.075	.6026	1.188	.6032	1.211	.6037	1.168
	.6041	1.055	.6046	1.173	.6050	1.196	.6053	1.153
	.6100	1.013	.6106	1.094	.6112	1.093	.6114	1.117
	.6117	0.966	.6122	1.038	.6126	1.14:	.6129	1.11:
	.6179	cloud	.6184	cloud	.6188	cloud	.6192	0.92:
	.6195	0.82:	.6201	0.86:	.6204	cloud	.6209	cloud
	.6248	0.60:	.6255	0.75:	.6260	0.95:	.6264	cloud
	.6267	cloud	.6272	0.71:	.6277	0.77:	.6279	0.79:
	.6307	0.39:	.6312	0.59:	.6315	0.72:	.6319	cloud
	.6345	0.33:	.6350	0.51:	.6353	0.59:	.6357	0.65:
HD 16769	.5845	−.905	.5850	−.633	.5854	−.501	.5857	−.320
	.6082	−.936	.6086	−.651	.6091	−.509	.6095	−.337
	.6233	−.95:	.6238	−.66:	.6241	−.51:	.6244	−.32:

The resulting light curves are shown in Figure 1. While clouds affected the latter observations, it is clear that this eclipse does not show a flat bottom. Other recent eclipses also do not show the flat-bottom effect (Davis 1996). Our light curves also show some evidence for the "light instabilities" that have been noted by others (e.g. Olson 1982a, 1982b, Hegedüs 1989, Davis 1996). The average from applying the method of bisecting chords to the four individual light curves yields the following time of minimum:

$$\mathrm{JD}_{Helio} = 2450425.6004 \pm 0.0002.$$

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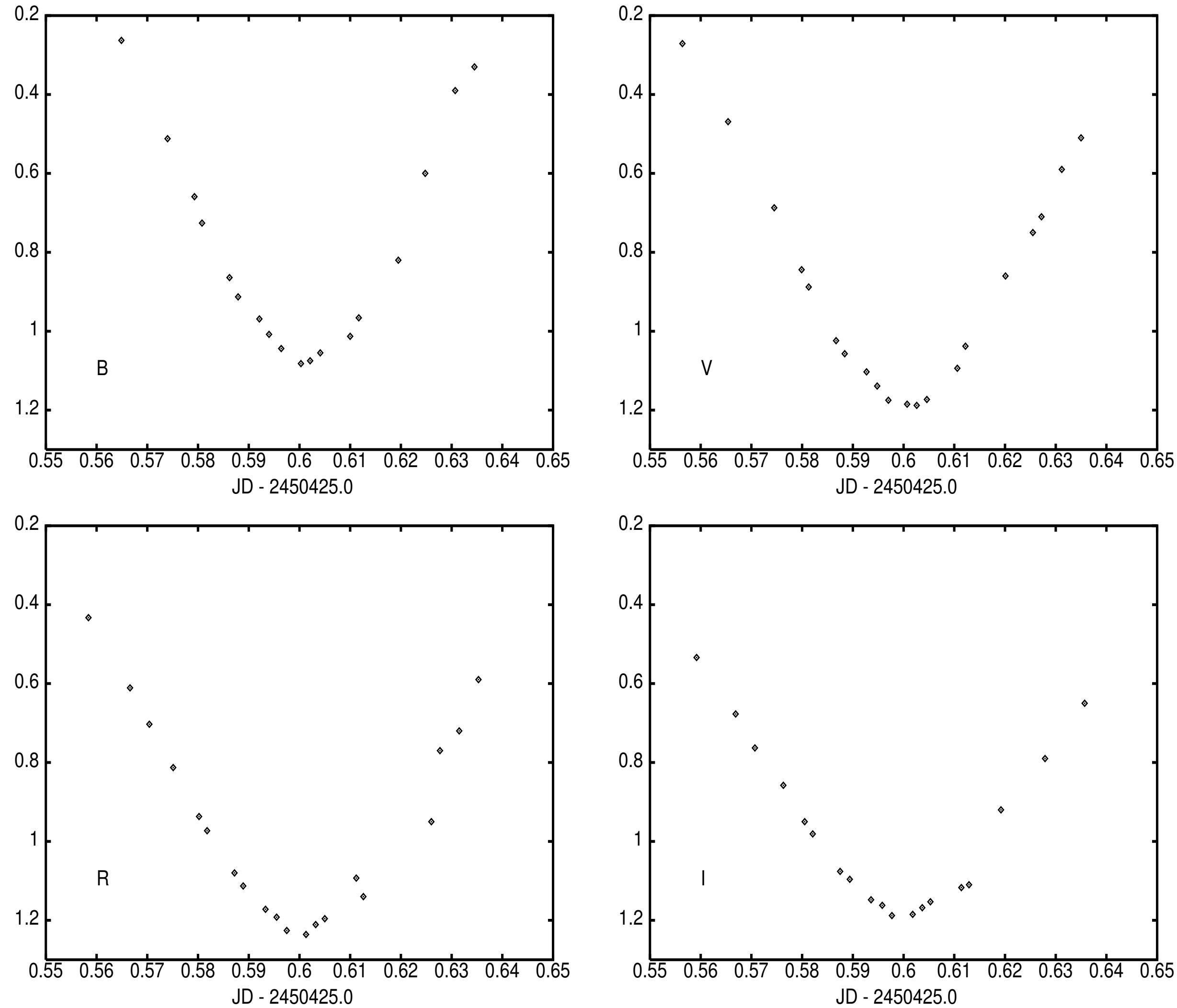

Figure 1. The differential light curves in BVRI (y-axis in mag)

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PHOTOMETRIC AND POLARIMETRIC OBSERVATIONS OF 17 DOUBLE AND MULTIPLE STARS

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We have performed a photometric and polarimetric monitoring of 17 double and multiple stars within the framework of scientific cooperation between the Byurakan Observatory (Armenia) and Observatory "Ramon Maria Aller" (Spain).

The observations have been made with the photopolarimeter attached to the AZT-14 50-cm telescope of Byurakan Observatory during January–July of 1997. This photopolarimeter works in the regime of intensification of the direct current. It can be used either as a photoelectric photometer (without the polaroid) or as a photopolarimeter (with a polaroid). The maximum sensitivity of the used photomultiplier lies in the wavelength interval 4000–4400 Å. The observations have been done in the U, B, V, R bands. A more detailed description of the method and instruments has already been given by Eritsian & Nersisian (1984).

In Table 1 (i) the name of star, (ii) the period of observations, (iii) the mean value of magnitudes in U, B, V, R bands and (iv) the number of photometric and polarimetric measurements are presented.

The first 4 stars in Table 1 are components of known long period variables. The separation between the primary stars and their comparison are between 46 and 208 arcseconds (Proust *et al.* 1981). For these four stars only photometric observations have been done.

The preliminary analysis of photometric and polarimetric observations of these 17 stars allows to detect light variations of two of them (SAO 64769 and SAO 87297) and intrinsic light polarization of SAO 88631. For some other observed stars the light variation can be suspected only: the amplitude of light variation of these stars is less than $3-5\ \sigma$. For 16 observed stars the degree of light polarization is less than 0.3 %.

The results of photometric observations for the stars SAO 64769 and SAO 87297 are presented in Table 2. The columns of Table 2 respectively give: (i) the name of the star, (ii) the date of observation, (iii) the observed magnitude in the U, B, V, R bands and (iv) the photometric uncertainties of measurements in U, B, V, R bands.

As one can see from the data given in Table 2 a real light variation of these two stars is detected.

In Table 3 the results of polarimetric observations of the star SAO 88631 are presented. The uncertainties in the polarimetric measurements are $\sigma_{P,(UBVR)} = 0.1 - 0.2$ %,

Table 1: Data of programme stars

Star	Observing period 1997	Mean magnitude U	B	V	R	n
R Gem (comp.)	13.01–12.02	–	10.85	10.91	–	10
S Ori (comp.)	13.01–31.01	–	8.68	8.05	–	5
R Aur (comp.)	13.01–12.02	–	9.74	8.52	–	9
U Cam (comp.)	13.01–12.02	–	9.37	9.07	–	9
SAO 64769	12.03–13.05	4.18	4.00	4.21	5.00	12
SAO 78155	13.03–14.05	8.97	8.96	9.98	9.00	11
SAO 79804	12.03–14.05	–	8.11	7.50	6.95	9
SAO 82650	13.03–12.05	7.25	6.42	6.08	6.22	
SAO 45051	18.03–07.05	–	10.85	10.02	10.32	2
SAO 78407	18.03–07.05	–	8.04	8.04	8.60	2
AGK 191058	29.05–13.07	–	7.83	7.74	8.05	15
SAO 64000	12.05–31.05	–	10.25	9.82	9.74	6
SAO 66759	29.05–13.07	–	9.22	9.22	9.59	16
SAO 87297	30.05–10.07	–	8.89	8.97	9.56	7
SAO 88631	05.06–12.07	–	7.14	6.90	7.41	8
SAO 107425	13.06	–	5.34	5.42	6.01	1

Table 2: Photometric observations of SAO 64769 and SAO87297

Star	Date	Brightness [m] U	B	V	R	σ [m] U	B	V	R
SAO 64769	12.03.97	4.21	4.05	4.35	4.95	0.02	0.01	0.01	0.02
	14.03.97	4.18	3.99	4.25	4.90	0.02	0.01	0.01	0.02
	16.03.97	4.22	4.01	4.25	4.93	0.02	0.01	0.01	0.02
	18.03.97	4.20	4.02	4.25	4.96	0.02	0.01	0.01	0.02
	19.03.97	4.16	4.00	4.25	4.90	0.02	0.01	0.01	0.02
	05.05.97	4.16	4.00	4.25	4.90	0.02	0.01	0.01	0.02
	06.05.97	4.25	3.91	4.21	5.12	0.02	0.01	0.01	0.02
	09.05.97	4.07	4.12	4.17	4.97	0.02	0.01	0.01	0.02
	10.05.97	4.00	4.06	4.21	4.97	0.02	0.01	0.01	0.02
	11.05.97	4.31	4.04	4.22	5.18	0.02	0.01	0.01	0.02
	12.05.97	4.25	3.82	3.99	5.01	0.02	0.01	0.01	0.02
	13.05.97	4.17	3.95	4.07	5.07	0.02	0.01	0.01	0.02
SAO 87297	30.05.97	–	8.75	8.85	9.45	–	0.02	0.02	0.03
	01.06.97	–	8.73	8.85	9.45	–	0.02	0.02	0.03
	03.06.97	–	8.75	8.85	9.45	–	0.02	0.02	0.03
	05.06.97	–	8.78	8.90	9.50	–	0.02	0.02	0.03
	09.06.97	–	8.80	8.91	9.50	–	0.02	0.02	0.03
	08.07.97	–	9.19	9.20	9.80	–	0.02	0.02	0.03
	10.07.97	–	9.22	9.25	9.81	–	0.02	0.02	0.03

Table 3: Polarimetric observations of SAO 88631

Date	P [%]				θ			
	U	B	V	R	U	B	V	R
05.06.97	1.5	0.7	0.4	0.6	2	1	2	178
07.06.97	1.3	0.8	0.4	0.5	2	1	2	178
10.06.97	1.4	0.6	0.4	0.7	3	1	2	177
12.06.97	1.3	0.7	0.3	0.7	2	2	3	177
13.06.97	1.4	0.7	0.4	0.7	2	1	2	178
08.07.97	1.5	0.7	0.4	0.6	2	1	2	178
11.07.97	1.4	0.7	0.5	0.6	2	2	3	178
12.07.97	1.4	0.6	0.4	0.7	2	1	2	177

$\sigma_{\theta,(UBVR)} = 1 - 2$ degrees. Such values of uncertainties in determination of the degree of light polarization allows to detect the light polarization only higher than $0.3 - 0.5$ %. For the other 16 stars no light polarization has been detected. In any case their polarization is smaller than $0.3 - 0.5$ %.

Table 3 gives the following data: (i) the date of observations, (ii) the observed degree of the light polarization (%) in the U, B, V, R bands and (iii) the angle θ. The wavelength dependence of light polarization of SAO 88631 and the absence of light polarization for the observed background stars show, that the detected light polarization has intrinsic character. It is a direct evidence of the existence of a circumstellar envelope near the star SAO 88631.

The study of photometric and polarimetric observations of the stars given in Table 1 in more detail will be done later.

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PHOTOMETRIC OBSERVATIONS OF VW CEPHEI IN 1996

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VW Cephei (HD 197433) is a W-type W UMa-type eclipsing binary with an orbital period of P = $0\overset{d}{.}2683$. It consists of chromospherically-active components of spectral types of G5V + G8V. The light curve of VW Cep is frequently asymmetric, and these asymmetries may be the result of large starspots covering significant fractions of the stars' surfaces (Guinan & Giménez, 1993). Because of its brightness, short period, and changing period and light curve, VW Cep is a favorite variable star for photometric studies. According to Vinkó *et al.* (1993), VW Cep has been the most frequently studied object appearing in the *IBVS* over the last 35 yrs.

Photoelectric photometry of VW Cephei was obtained during 9 nights from late September to early November 1996 at the Villanova University Observatory. The observations were carried out with the 38-cm Cassegrain reflector equipped with a photoelectric photometer using a refrigerated EMI 9658 photocell. HD 197665 (F2; $m_v = +7.6$ mag), served as the chief comparison star. A Strömgren y (550nm) filter and an intermediate band r (660nm) filter were used. These filters have bandpasses of full width half maximum of 26 nm and 28 nm, respectively. Nearly 600 observations were recorded in each band-pass. The integration time for each observation was 20 seconds, and the observation sequence was the usual sky-comparison-variable-comparison-sky routine. The data were corrected for atmospheric extinction, and the observed times were converted to heliocentric Julian dates. Figure 1 shows the resulting light curves for VW Cep, in which the phases were computed using the light elements of Lloyd *et al.* (1992):

$$MinI = HJD\ 2446822.5233 + 0\overset{d}{.}2783099 \times E \tag{1}$$

Table 1 lists the values of the delta magnitudes (in the sense *variable* minus *comparison* star) of the light curve extrema.

Table 1

	$\Delta m(v-c)$ for intermediate band r (660 nm)	$\Delta m(v-c)$ for Strömgren y (550 nm)
Primary Minimum	+0.272	+0.564
Maximum I	−0.042	+0.227
Secondary Minimum	+0.191	+0.475
Maximum II	−0.076	+0.181

Both Figure 1 and Table 1 show that there are asymmetries in the light curves in which the maximum following primary eclipse is fainter than the corresponding maximum that follows secondary eclipse (Max II) by 0.034 mag in r and 0.046 mag in y. It is likely that the asymmetries are the result of intense chromospheric activity (Vinkó *et al.*, 1993) and the presence of cool starspots located primarily on the photosphere of the larger, more massive component of the system (Abbott & Rumignani, 1994).

The times of minima were found from our observations using a parabolic least squares fit to the data for both filters. The times of minima are presented in Table 2. These are mean times of minima obtained for both filters. The number of cycles elapsed (E) and O−C residual values are presented in Table 2; these quantities were determined using the ephemeris given above.

Table 2

HJD 2450000+	Type	E	(O−C)
363.7143	Primary	12724.0	$-\,0^{\mathrm{d}}.0242$
372.6210	Primary	12756.0	$-\,0^{\mathrm{d}}.0234$
388.6196	Secondary	12813.5	$-\,0^{\mathrm{d}}.0276$
390.5693	Secondary	12820.5	$-\,0^{\mathrm{d}}.0261$

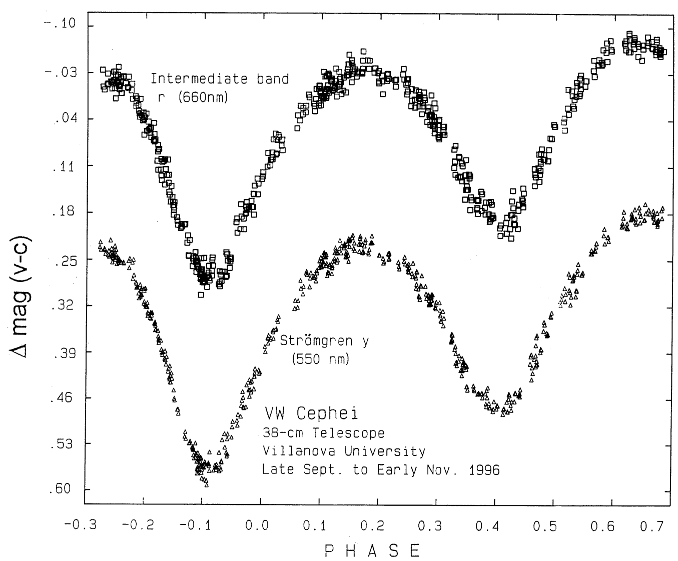

Figure 1. The r (660 nm) and y (550 nm) light curves of VW Cep are plotted for Fall 1996. Delta-magnitudes are plotted versus orbital phase in which the phases are computed using ephemeris of Lloyd *et al.* (1992).

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OPTICAL DETECTION OF THE INTENSE 1995 NOVEMBER FLARE IN UX ARIETIS

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On 19 Nov. 1995 (UT 10:45) (JD 2450040.9479), Dupree and Brickhouse (1996) detected the brightest RS CVn flare ever observed with the Extreme Ultraviolet Explorer (EUVE) satellite while observing the chromospherically active binary star UX Arietis (HD 21242, G5 V/K0 IV). At that time, the count rate in the Deep Survey (DS) instrument (roughly 70Å to 140Å) was ten times higher than during earlier observations of the star on 7–10 Nov. 1995. The DS instrument detected two additional, weaker flares during the decay phase. By the end of the observing run on 25 Nov. 1995 (UT 11:00) (JD 2450046.9583), UX Ari was still three times above its quiescent level. Dupree and Brickhouse (1996) report that the EUVE spectra of the event are dominated by emission lines of He II and Fe XX, XXIII, and XXIV.

UX Ari was also observed during the period 16–25 Nov. 1995 by Beasley *et al.* (1997) with the National Radio Astronomy Observatory Very Large Array and Very Long Baseline Array. Strong, highly variable microwave emission was detected beginning on 17 Nov. (UT 11:00) (JD 2450038.9583), and multiple flaring events were detected throughout the remainder of the observing run. Further information about these observations can be obtained from tbeasley@aoc.nrao.edu. The first EUVE observation of the flare occurred two days after the start of the enhanced microwave emission.

We have observed UX Ari photometrically every year since 1976, first with manual telescopes and later with automatic photoelectric telescopes (APTs) as part of our program to document long-term changes in chromospherically active stars (see e.g., Henry *et al.* 1995). Since 1987, UX Ari has been observed each night in the Johnson B and V bands with the Vanderbilt/Tennessee State 16-inch APT in Arizona. The observations are made differentially with respect to the comparison star 62 Ari, corrected for differential extinction with nightly extinction coefficients, and transformed to the Johnson system with long-term mean transformation coefficients. Further details of the observing and data reduction procedures can be found in Henry (1995).

Our 16-inch APT observations of UX Ari taken just prior to, during, and just after the 1995 Nov. flare are tabulated in Table 1. Each observation listed is the mean of three consecutive differential magnitudes spanning less than five minutes. The first column gives the Heliocentric Julian Date of the observations. The second column gives the orbital phases computed with the ephemeris

$$JD_{conj} = 2,440,133.75 + 6.43791 \ \times \ E \qquad (1)$$

Table 1: 16-inch APT Photometric Observations of UX Ari

Julian Date 2400000+	Phase	ΔB	ΔV
50003.8763	0.1259	0.784	1.041
50004.8801	0.2818	0.674	0.900
50005.8812	0.4373	0.668	0.901
50007.8769	0.7473	0.736	0.987
50008.8776	0.9027	0.760	1.007
50009.8746	0.0576	0.810	1.075
50010.8801	0.2138	0.737	0.965
50011.8767	0.3686	0.659	0.885
50012.8795	0.5243	0.722	0.950
50013.8786	0.6795	0.751	0.988
50015.8735	0.9894	0.800	1.062
50016.8680	0.1439	0.774	1.028
50017.8661	0.2989	0.664	0.897
50018.8655	0.4541	0.681	0.910
50025.7988	0.5311	0.720	0.945
50030.9833	0.3364	0.651	0.881
50031.8096	0.4647	0.692	0.922
50032.9997	0.6496	0.737	0.986
50033.8293	0.7785	0.733	0.975
50033.9791	0.8017	0.732	0.972
50034.9866	0.9582	0.788	1.044
50037.9113	0.4125	0.671	0.900
50038.8219	0.5540	0.735	0.965
50039.8215	**0.7092**	**0.708**	**0.954**
50040.8159	**0.8637**	**0.729**	**0.985**
50043.8107	0.3289	0.661	0.899
50044.8213	0.4858	0.697	0.927
50045.8130	0.6399	0.732	0.964
50046.8368	0.7989	0.729	0.966
50047.7973	0.9481	0.787	1.048

from Carlos and Popper (1971), where zero phase is the conjunction with the G5 V component behind the K0 IV star. Columns 3 and 4 give the differential B and V magnitudes, respectively. Observations acquired during the flare are given in bold font.

The B observations in Table 1 are plotted versus orbital phase in Figure 1. Closed circles represent the observations taken during the four orbital cycles immediately preceding the flare and establish the basic shape of the pre-flare light curve. The circled points represent the observations acquired on four consecutive nights during the orbital cycle in which the flare occurred. The first two circled points, taken at JD 2450037.9113 and 2450038.8219, occur before the start of the flare and are still at the pre-flare brightness level. Note, however, that the second of these two observations was made only 3.3 hours before the start of the microwave flare event observed by Beasley *et al.* (1997). The last two circled points, taken at JD 2450039.8215 and JD 2450040.8159, were acquired during the flare; they show elevations above the pre-flare light level of about 0.03 and 0.015 mag, respectively. A similar plot of our V data show elevations in V for these two observations of about 0.02 and 0.01 mag, respectively. The open circles in Figure 1 represent the observations taken during the orbital cycle immediately after the flare and show that the light curve has returned to its pre-flare levels. The first of these post-flare observations was not acquired until JD 2450043.8107, three days after the second flare observation. The observed rate of decay implies, however, that the optical enhancement probably became unobservable soon after the second flare observation. Therefore, we estimate the duration of the optical component of the flare to be about two days. It is also likely that the maximum of the optical activity occurred between our observations on JD 2450038 and JD 2450039.

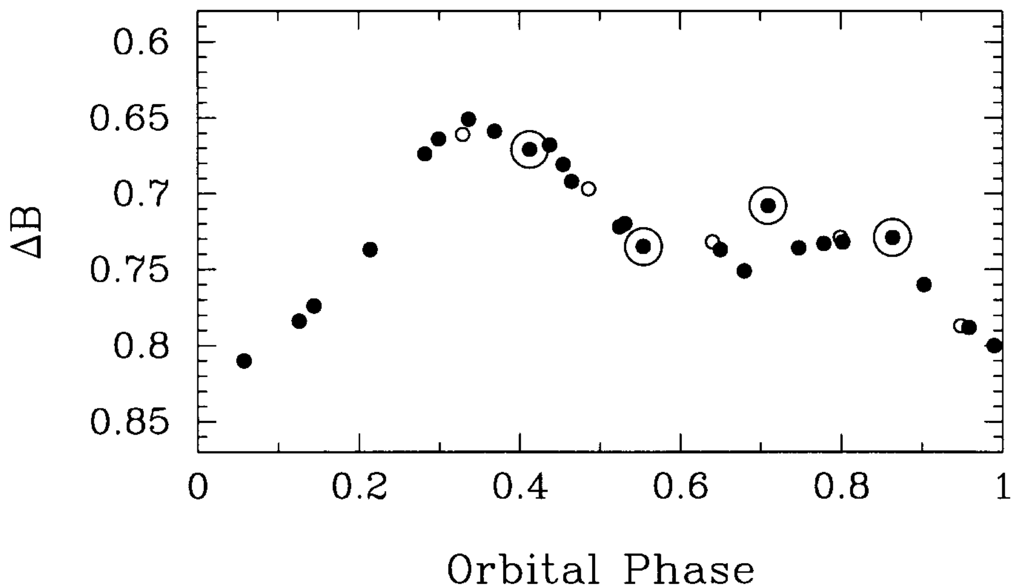

Figure 1. Photometry of UX Ari acquired just before, during, and just after the flare. Symbols are defined in the text.

The light from UX Ari varies continually with an amplitude between about 0.05 and 0.25 mag (Landis *et al.* 1978; Strassmeier *et al.* 1989) due to rotational modulation of star spots. Brightness changes are accompanied by significant (B−V) color changes but in the sense that the star gets redder when it gets brighter due to the light contribution of the G5 V star. The rotation period of UX Ari, as deduced from the brightness variations, is equal to the orbital period. In fact, UX Ari is so well synchronized that the minima of the light curves always occur near orbital phase 0.0, i.e., the most spotted hemisphere of the K0 IV star is always turned away from the G5 V star. (The reflection effect is expected to contribute only about 0.03 mag to the brightness difference between the two hemispheres of the K star.) Amplitude changes over the years are accompanied by relatively little change in mean magnitude of the star, indicating that the amplitude changes are the result primarily of redistribution of a roughly constant total spotted area. UX Ari underwent a rather sudden redistribution of spots during the orbital cycles immediately following those plotted in Figure 1. The light curve brightened by a few percent between phases 0.5 and 0.8, roughly where the flare had occurred, while fading by a similar amount between phases 0.3 and 0.5. The light curve then appeared roughly constant at $\Delta B = 0.7$ between phases 0.3 and 0.8.

Table 2: Optical-Flare Amplitudes in UX Ari

Julian Date 2400000+	Phase	U Amp (mag)	B Amp (mag)	V Amp (mag)	Source
45995.9885	0.5810	0.07	0.02	0.01:	Henry & Newsom (1996)
49686.8136	0.8765		0.11	0.06	this paper
49751.6928	0.9542		0.05	0.03	this paper
50039.8215	0.7092		0.03	0.02	this paper
50040.8159	0.8637		0.015	0.01	this paper

UX Ari is one of a small subset of extremely active RS CVn binaries in which Hα always appears in emission (Nations and Ramsey 1981). It is also one of only three stars from a survey of 69 chromospherically active stars in which Henry and Newsom (1996) found evidence of optical flare activity. In a total of 294 nightly observations from the Phoenix 10-inch APT, spanning 4.0 years between 1984.0 and 1988.0, they detected a single flare, with amplitudes of 0.07, 0.02, and 0.01 mag in U, B, and V, respectively, for a flare-detection rate of 0.0034 flares per nightly observation. We searched our 10-year data set from the 16-inch APT, extending from 1987.9 to 1997.2 and containing 760 nightly BV measurements of UX Ari, for signs of additional flares, following the techniques of Henry and Newsom (1996). We found only two other events, both during the 1994-95 observing season. Therefore, we derive an average flare-detection rate of 0.0039 flares per nightly observation for the 16-inch APT data set. Table 2 summarizes all of the known optical flare events in UX Ari.

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TRUE AND POSSIBLE CONTACT BINARIES IN THE HIPPARCOS CATALOGUE

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Contact binaries are the most frequent type of eclipsing binaries. Nevertheless, many of them escape detection because their inclination angles are small, and the light variations are below the general detection limit of (mainly photographic) searches for variable stars. An unpublished study of the distribution of inclination angles of contact binaries shows that the probability of discovery drops dramatically below 75 degrees, and becomes nearly zero at 60 degrees (Duerbeck 1997). In recent years, low amplitude contact binaries were found in CCD studies of galactic clusters and the bulge (see, e.g., Rucinski & Kaluzny 1994, Rucinski 1997), but no systematic all-sky-survey is available until now.

The photometric survey of the HIPPARCOS satellite has confirmed many variables, and has produced a substantial number of new ones. I have surveyed the list of periodic variables in the Variability Annex of the HIPPARCOS Catalogue (ESA 1997) for known and new contact binaries. Stars classified as "EW" were examined, and a few dubious cases were rejected. Of the 108 remaining contact binaries observed by HIPPARCOS, 34 were discovered or newly classified as contact binaries by the HIPPARCOS team.

Are there more contact binaries in the HIPPARCOS catalogue? The Variability Annex contains a number of low amplitude variables of short period described only by "P" for periodic variable. These objects might be pulsating stars of low amplitude of types RRC, DSCT/DSCTC, or BCEP, or contact binaries seen at small inclination angles. As such they belong to the variable star group ELL – rotating ellipsoidal variables. The definition of type ELL is somewhat ambiguous, since it comprises contact binaries as well as EB and EA binaries with low inclination angles. Most stars classified as ELL (in the Variability Annex and elsewhere) have maxima of unequal height, which shows that binaries with a strong O'Connell effect are preferentially included in the ELL group. Without spectroscopic information, systems with maxima of equal height and displaying sinusoidal light curves might easily be taken for pulsating variables with half the adopted orbital period.

In order to provide a working list of contact binary candidates for spectroscopic verification, I have plotted a period–colour relation for the "true" HIPPARCOS contact binaries; for a discussion of the period–colour relation, see Rucinski (1993). The $(B - V)$ values from the HIPPARCOS catalogue are not corrected for interstellar extinction, which is expected to be small. The systems are shown in Fig. 1 as open circles. All low-amplitude variables of short period with sinusoidal light curves were also entered, in this case, with period values doubled. These data are shown as filled circles.

The “true” contact binaries, together with the majority of low amplitude variables (filled black circles), match the well-known broad band from the “red” short period contact binaries to the “blue” long period binaries. A small subgroup is found at generally short periods and blue colours (grey filled circles): These variables may consist mainly of DSCT and RRC variables, and are designated, in the present context, as “pulsating” stars. The borderline can be assumed as a polygon through the bluest confirmed contact binaries; another possibility is the use of the Blue Short Period Envelope defined by Rucinski (1997), transformed to the (B−V) index (see Rucinski & Duerbeck 1997b). Both methods separate well the blue pulsating stars from the contact binaries. The remaining sample of contact binary candidates will, however, still be contaminated by pulsating stars, since the RRC stars extend to redder colours and longer periods. Space motions, parallaxes, and spectroscopic investigations are needed for a complete separation of the two groups.

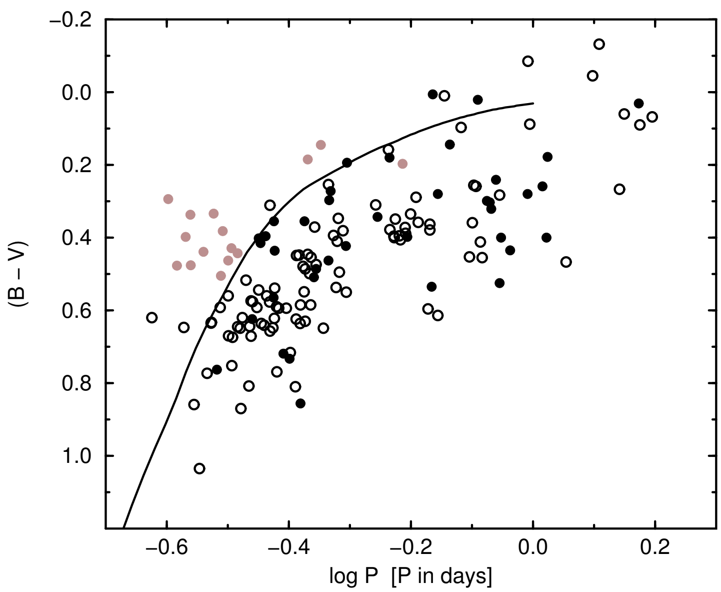

Figure 1. The period–colour diagram of confirmed contact binaries (open circles), suspected contact binaries (filled circles, black) and suspected pulsating variables (filled circles, grey). The latter ones fall outside the band defined by the true contact binaries. The short-period blue envelope of contact binaries (Rucinski 1997) is also shown.

Table 1: List of periodic variables in the Variability Annex of the HIPPARCOS Catalogue, which are either contact binary stars (EW) or pulsating stars.

HIP	GCVS	P (days)	B − V	range (m_{Hp})	spectral type	comment
2005	BQ Phe	0.4370	0.509	10.473−10.594	F3/5 V	EW
2274	CL Cet	0.6216	0.398	9.881− 9.999	F2 V	EW
7682	CE Hyi	0.4408	0.486	8.481− 8.527	F5 V	EW
8821	V778 Cas	0.8808	0.525	8.943− 9.090	F0	EW; vis. bin
11934	WY Hor	0.3989	0.733	9.516− 9.705	G2 IV/V	EW
17042	V579 Per	0.4656	0.272	7.875− 7.942	A0	EW
17826		0.8863	0.400	8.271− 8.315	F0	EW; vis. bin

Table 1 (cont.)

HIP	GCVS	P (days)	$B-V$	range ($m_{\rm Hp}$)	spectral type	comment
18151	CY Cam	1.0520	0.400	8.432− 8.518	B1 III, B8	EW (early type)
18474	V1131 Tau	0.3080	0.505	8.826− 8.897	F0	puls
22326	HV Eri	0.4218	0.355	8.368− 8.463	A5	EW or puls; vis. bin
22454	V1359 Ori	0.3643	0.396	8.524− 8.569	F0	EW or puls
28440	AN Men	0.4620	0.463	9.358− 9.539	F5 V	EW
28778		0.8400	0.299	7.653− 7.689	A9 V	EW
29186	V1383 Ori	0.7302	0.144	8.767− 8.872	A3 V	EW; vis. bin
29589	PV Gem	0.3762	0.355	7.580− 7.635	F0	EW or puls; vis. bin
34401	V752 Mon	0.4629	0.297	6.979− 7.006	F0	EW; vis. bin
37197	V345 Gem	0.2748	0.476	7.819− 7.883	F0	puls; vis. bin
43071	OQ Vel	0.5813	0.180	7.736− 7.774	A5 V, A3 IV	EW; vis. bin
44800	DO Cha	0.6814	0.535	7.739− 7.777	F7 V	EW
45693	GG UMa	0.2697	0.398	8.662− 8.720	F5	puls
46223		0.9794	0.280	7.067− 7.098	A3	EW
50775	V344 Vel	0.2995	0.334	7.968− 8.005	F0 IV	puls
51361	GS UMa	0.3280	0.443	8.751− 8.800	F8	puls
51677	ET Leo	0.3465	0.624	9.594− 9.721	G5	EW
52624	V353 Vel	0.4953	0.194	7.688− 7.728	A3 IV/V	EW
53708	V527 Car	0.4273	0.185	9.039− 9.090	A3m, A7-9	puls or EW; vis. bin
54165	HH UMa	0.3755	0.565	10.584−10.798	F8	EW
62919	DT Cru	0.9168	0.435	10.022−10.210	B3	EW (early type)
63076		0.8490	0.303	5.283− 5.324	A5n	EW
69300		0.8688	0.241	7.795− 7.869	A4 V	EW
73047	TU UMi	0.3771	0.436	8.837− 8.893	F2	EW or puls
75203	FI Boo	0.3900	0.719	9.596− 9.702	G5	EW
81650		0.8532	0.321	6.370− 6.388	A9 V	EW
82883	V925 Her	0.2610	0.477	10.125−10.233	F5 V	puls
82967	V2357 Oph	0.4156	0.856	10.671−10.787		EW
83370	V929 Her	0.2884	0.439	8.061− 8.110	A5	puls
86294	V1084 Sco	0.3033	0.763	9.067− 9.198	G6 V	EW
86487	V2382 Oph	1.0558	0.178	7.260− 7.292	B3 Vne	EW
87541	GW Dra	0.2524	0.294	9.320− 9.382	F2	puls
92699	V1003 Her	0.4933	0.423	9.810− 9.904	A7	EW
92776	V4408 Sgr	1.4894	0.031	8.291− 8.377	B7 III	EW (early type)
97600	V1464 Aql	0.6978	0.280	8.685− 8.754	A2	EW
99037	IN Dra	0.2743	0.337	8.053− 8.090	F0	puls
99365	BD Cap	0.3204	0.429	7.514− 7.573	A9 III	puls
100187	DE Oct	0.5556	0.343	9.193− 9.266	A9 IV	EW; vis. bin
101862	V2129 Cyg	0.3098	0.382	8.369− 8.449	F8	puls
103803	V388 Pav	0.3165	0.463	8.813− 8.880	F5 II	puls
105249	AW Mic	0.6113	0.197	9.110− 9.198	A0 III:W	see text
108741	BX Ind	0.3552	0.402	7.937− 8.029	F2 V	EW or puls
109191	V445 Cep	0.4487	0.145	6.875− 6.903	A0	puls or EW
110622	V407 Lac	0.8113	0.021	8.309− 8.386	A0	EW
114189	V342 Peg	1.0358	0.259	6.005− 6.063	A5 V	EW; P=0.7853?
115262	V459 Cep	0.3576	0.415	7.723− 7.754	F2	EW or puls
117111	V395 And	0.6847	0.006	7.570− 7.607	A0	EW; vis. bin

A period–colour–luminosity calibration of contact binaries, based on Hipparcos data, is given by Rucinski and Duerbeck (1997a,b). An analysis of space motions is in progress. The present list (Table 1) gives preliminary classifications – EW, pulsating, or unclear cases "EW or puls" and "puls or EW". Spectroscopic investigations are needed to verify the true nature of the listed stars.

It is encouraging to see that most objects with spectroscopically assigned high luminosity classes fall indeed into the blue region of the pulsating stars, a notable exception being HIP 105249 (AW Mic). Its Hipparcos parallax yields $M_{\mathrm{Hp}} = +1.2^{+0.85}_{-1.45}$, which is compatible with either a contact binary or an RR Lyrae star. This star is, however, known as a field Horizontal Branch star and a suspected RR Lyrae variable (cf. Kodaira and Philip 1984). Another case is HIP 92776 (V4408 Sgr), which has the spectral type B7 III and may be an early type contact binary.

The inclination angles of most contact binary candidates will be small and difficult to determine, thus, spectroscopic studies will only be of limited use, spectroscopic verifications will, however, yield the necessary data for the determination of the space density of contact binaries in the solar neighborhood.

Acknowledgements. It is a pleasure to acknowledge the gigantic task of M. Perryman and his colleagues for the production of this most valuable astronomical tool: the Hipparcos Catalogue. I am also very grateful to Slavek Rucinski (CFHT) for valuable comments on the manuscript, and to Thomas Schimpke (Astronomical Institute Muenster) who instructed my PC to do things which were essential for the preparation of this paper.

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NEW BRIGHT FLARE STAR IN THE SOLAR VICINITY, COU 14 = SAO 107425

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During the photometric and polarimetric monitoring of double and multiple stars two flares have been detected on COU 14 = SAO 107425, which is known as a bright variable binary with the spectral type F2 III-IV (Mermilliod, 1987). The separation between the two components is 0.″3 (Holden, 1976).

The observations have been carried out with the photopolarimeter attached to the AZT-14 50cm telescope of Byurakan Observatory. This photopolarimeter operates in the regime of intensification of the direct current. It can be used as a photoelectric photometer if the polaroid is removed. A more detailed description of the method and instruments has already been given by Eritsian and Nersisian (1984).

Table 1: U, B, V, R photometry of COU 14

Date	m			
	U	B	V	R
13 June 1997	5.65	5.69	5.36	5.48
25 July 1997	5.75	5.75	5.42	5.70
27 July 1997	5.77	5.75	5.36	5.60
28 July 1997	5.75	5.75	5.40	5.71
31 July 1997	5.78	5.74	5.37	5.61
22 August 1997	5.78	5.74	5.53	5.71

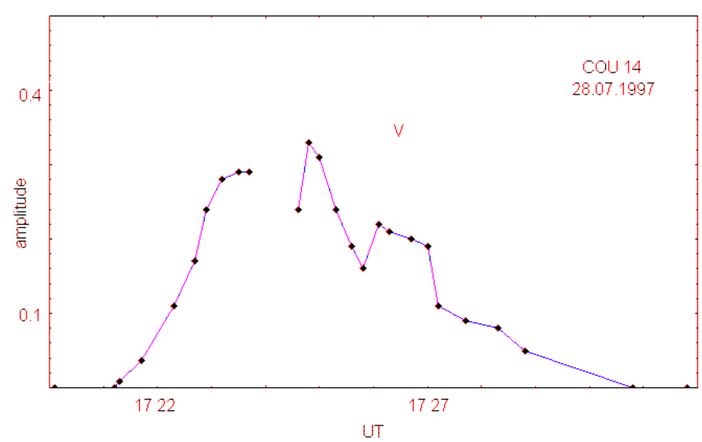

Figure 1.

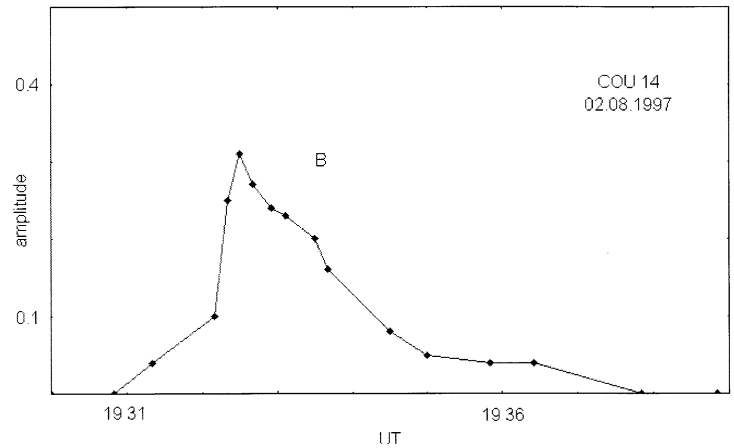

Figure 2.

Two flares have been detected on COU 14 on 28 July and 2 August in V and B bands, respectively. In Figures 1 and 2 the light curves of these flares are presented where their amplitudes and dates of observations are shown.

In Table 1 results of UBVR photometry of the star out of flares are presented: (i) the date of measurement and (ii) observed magnitudes in UBVR bands. As the accuracy of our photometric measurements in UBVR bands is $0\overset{m}{.}01$, from these data the slow variation in brightness can be suspected as well.

It is worth to point out that polarimetric observations have not shown light polarization for COU 14.

As one can see the star shows UV Ceti type brightness variation. However UV Ceti type stars in solar neighbourhood and in stellar aggregates have spectral types Ke – Me. The earliest spectral type among known flare stars is K1 found in Orion region (Natsvlishvili, 1987).

The flares detected on COU 14 can serve as a good evidence that UV Ceti stage occurs for stars of much earlier spectral types.

Further photometric and polarimetric investigation to study flare activity of COU 14 in more detail would be worth.

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1991 BVR$_C$I$_C$ LIGHT CURVES AND PERIOD STUDY FOR THE VERY SHORT PERIOD, ACTIVE W UMa SYSTEM, V743 SAGITTARII

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As a part of our continuing study of the characteristics of very short period eclipsing binaries and as a follow up to the preliminary report of 1990 (Samec and DeWitt), we have obtained well-covered BVRI light curves of V743 Sagittarii [HV 10263, RA (2000) = $17^{\rm h}43^{\rm m}56\overset{\rm s}{.}1$, D (2000) = $-28°29'54''$]. The early papers contain forty-eight timings of minimum light (Plaut 1958 and Swope 1940, Samec and DeWitt 1990). A further summary of the observing history of this neglected variable has been given previously (Samec and DeWitt 1990).

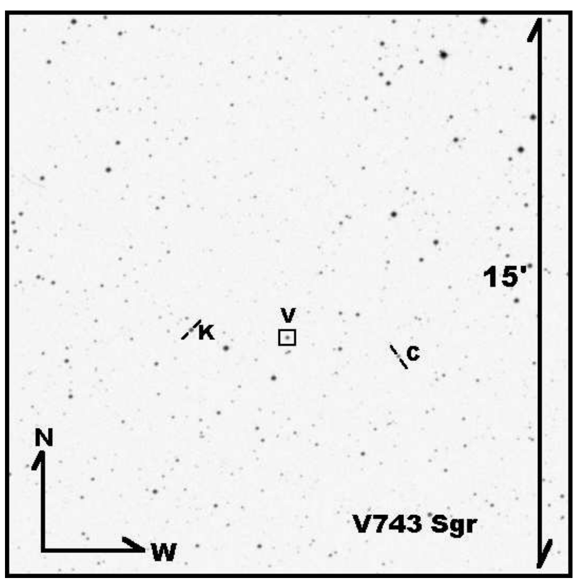

Figure 1. Finding chart (modified from the Digital Sky Survey image) of 743 Sgr, V, the comparison star, C, and the check star, K.

Our present observations were taken at Cerro Tololo InterAmerican Observatory with the 1.0 m Yale Reflector Telescope in conjunction with a Ga-As PMT on May 13 to 20,

1991. The comparison [RA (2000) = $17^h43^m42^s.6$, D (2000) = $-28°30'26''$], and check stars, [RA (2000) = $17^h44^m7^s.9$, D (2000) = $-28°29'40''$] are given C, and K in Figure 1 along with the variable, V. Some 350 observations were tak en in each pass band. Four new epochs of minimum light were determined from the observations made during two primary and two secondary eclipses. MWL has redetermined the four earlier times of minimum light from Samec and DeWitt (1990). These minima are given in Table 1 along with their probable errors in parentheses. An improved linear ephemeris was calculated, using all available data:

$$J.D.\ Hel\ Min\ I = 2448392.7141(24) + 0^d.276635806(57) \times E$$

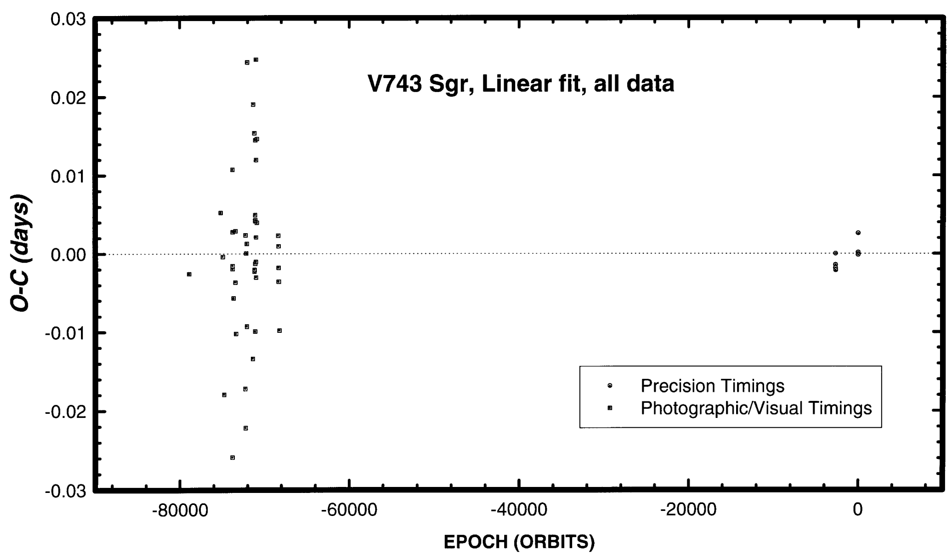

Figure 2. O−C residuals for all available timings of minimum light as calculated from the improved ephemeris.

The O−C residuals calculated from this ephemeris and all available timings of minimum light are shown in Figure 2. More timings of minimum light are needed to determine the period behavior of this system, both from photographic archives to fill in the large gap in the observations and from telescopic observations. Many W UMa binaries with a good data base show definite nonlinear period changes (usually quadratic), and this one may be no exception.

Our dereddening transformations indicate that V743 Sgr is a K0 spectral type variable. The BVRI light curves and the B−V and U−B color curves of V743 Sgr are shown as Figure 3 and 4 as differential standard magnitudes (variable−comparison) versus phase. The eclipse duration is ≈ 22 minutes (0.055P) for this very short period binary. Our simultaneous light curve solution (Wilson, 1990 and 1994) gave a component temperature difference of 354K, a mass ratio of 0.314 and a fill-out of 11%. A large polar cool star spot was determined. Also, the system has an active convective envelope with constantly changing spots as indicated by a comparison of our 1989 curves with the present, 1991 curves. For instance, the primary eclipse is definitely shallower and the O'Connell effect has reversed, in just two years! Do very short period W UMa systems mimic their larger cousins, the RS CVn-type binaries with regard to spot evolution? Only patrol projects of individual binaries will reveal the answer to this question.

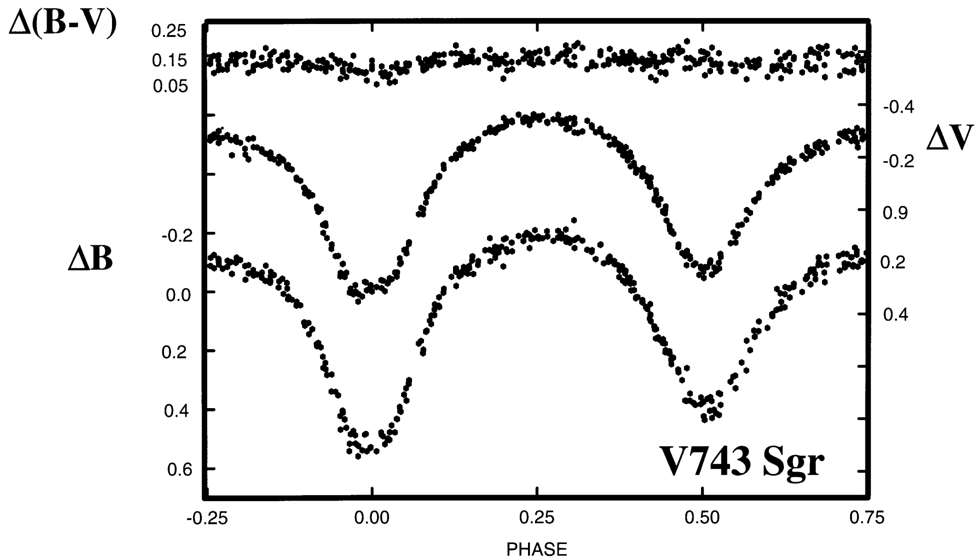

Figure 3. B, V light curves and B−V color curve for V743 Sgr as standard magnitude differences, variable minus comparison star.

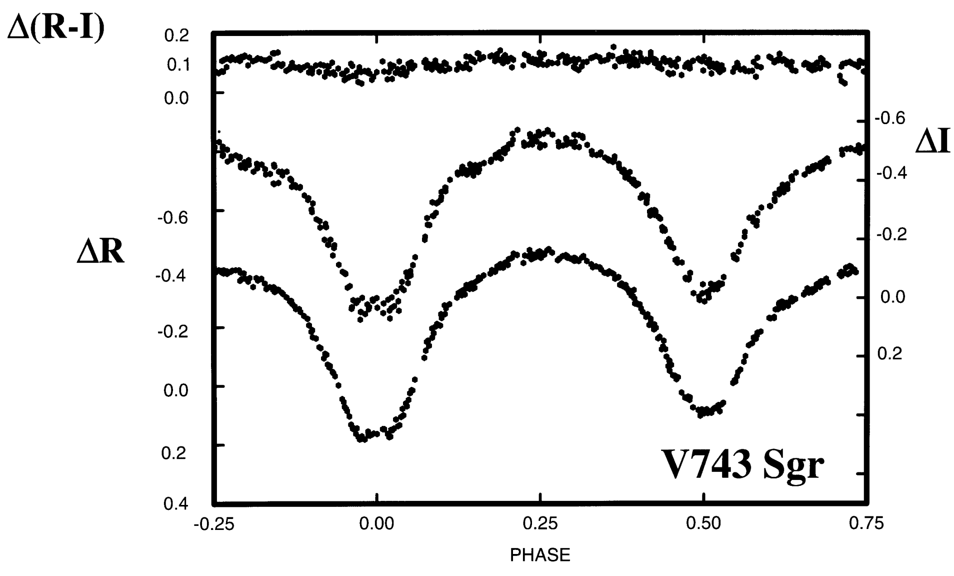

Figure 4. R, I light curves and R−I color curve for V743 Sgr as standard magnitude differences, variable minus comparison star.

Table 1: Epochs of Minimum Light, V743 Sgr

JD Hel. 2440000+	Min	Cycles	O−C	Source
7655.8946(4)	II	−2663.5	−0.0000	SD
7656.8614(1)	I	−2660.0	−0.0015	SD
7657.6909(1)	I	−2657.0	−0.0019	SD
7658.6588(8)	II	−2653.5	−0.0021	SD
8392.7142(3)	I	0.0	0.0001	PO
8392.8550(8)	II	0.5	0.0026	PO
8393.6849(6)	II	3.5	0.0026	PO
8393.8205(4)	I	4.0	−0.0002	PO

Sources: SD: Samec and DeWitt 1990,
PO: Present Observations

Much of this work was done as a part of an undergraduate research project by MWL and RGS in the summer and fall of 1996.

This research was partially supported by a grant from NASA administered by the American Astronomical Society.

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UBV PRECISION LIGHT CURVES OF THE NEAR OR SHALLOW CONTACT BINARY, HW PERSEI

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As a part of our recent studies of particular eccentric binary candidates (Hegedüs, 1988), we have obtained UBV photoelectric light curves of HW Persei [S 3381, 54.1943 $\alpha(2000) = 3^{\rm h}58^{\rm m}46\overset{\rm s}{.}1$; $\delta(2000)=+44°44'04''$]. Hoffmeister (1943) discovered the variability of HW Per and identified it as an Algol variable. Van de Voorde (1947) published 5 timings of minimum light and gave a photographic range of 13–13.7. Gessner (1966) published a photographic light curve with the secondary eclipse displaced to phase 0.45, along with several timings of minimum light and an ephemeris:

$$\text{JD Hel. Min. I} = 2428023.527 + 0\overset{\rm d}{.}634828 \times E. \tag{1}$$

In addition, BBSAG observer Marek Wolf (1995), has provided one precision (CCD) epoch of minimum light.

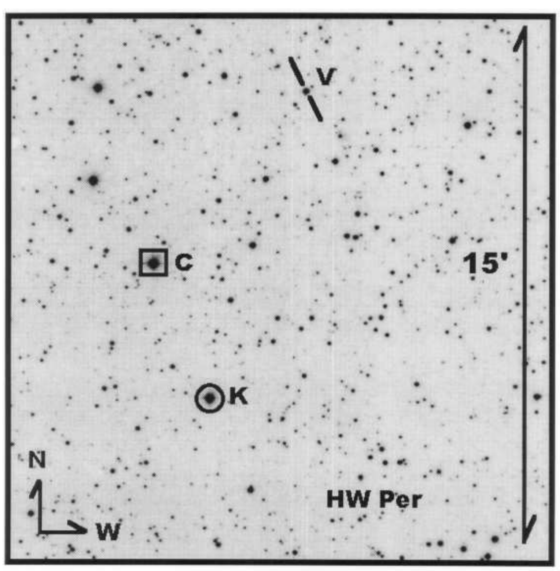

Figure 1. Finding chart for HW Per modified from a Digitized Sky Survey image

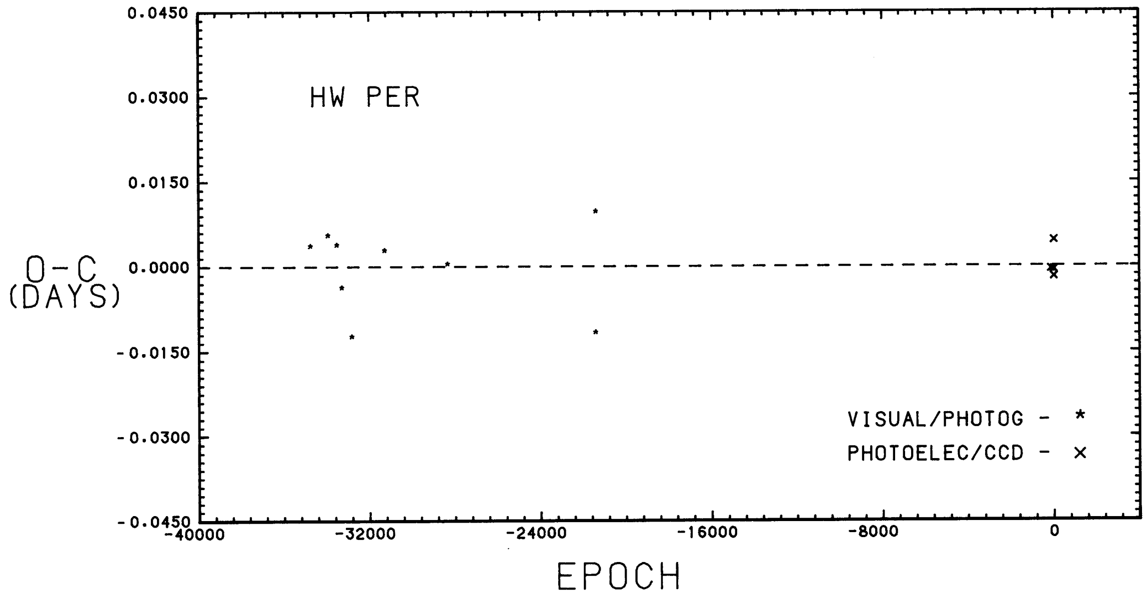

Figure 2. O−C residuals as calculated from equation 2

Table 1: Epochs of minimum light, HW Per

JD Hel 2450000+	Cycles	Minimum	Weight	O−C	Ref
13.350	−133.0	I	1.0	−0.0006	MW
97.7831(5)	0.0	I	1.0	−0.0007	PO
98.7340(12)	1.5	II	0.5	−0.0019	PO
100.6450(11)	4.5	II	0.5	0.0045	PO

Note: MW = Wolf 1995, PO = Present Observations

Our present observations were taken on 1996 January 14–19 at Lowell Observatory, Arizona. The 0.79-m Lowell telescope was used in conjunction with a thermoelectrically cooled S-13 type PMT and a set of standard UBV filters. Two nearby non-varying stars were used as comparison ($\alpha(2000) = 03^{\rm h}59^{\rm m}10\overset{\rm s}{.}7$, $\delta(2000) = 44^\circ 39' 24''$) and check ($\alpha(2000) = 03^{\rm h}59^{\rm m}2\overset{\rm s}{.}5$, $\delta(2000) = 44^\circ 35' 37''$) stars. The variable, comparison and check stars are given as V, C and K, respectively, on the finding chart given as Figure 1.

Our photometry and transformations give a magnitude range of V = 12.50–13.31, B−V = 0.55–0.60 for the variable, and V = 10.47, B−V = 0.459 and V = 9.72, B−V = 0.31 for the comparison and check stars, respectively. Dereddening calculations give photometric spectral types of A8 (phase 0.5), F4 and A7 for the variable, comparison and check stars, respectively.

Three mean epochs of minimum light were determined from observations made during one primary and two secondary eclipses. Bisection of chords was utilized in their determination. These epochs of minimum light are given in Table 1 accompanied by their probable errors in parentheses, along with the one by Wolf (1995).

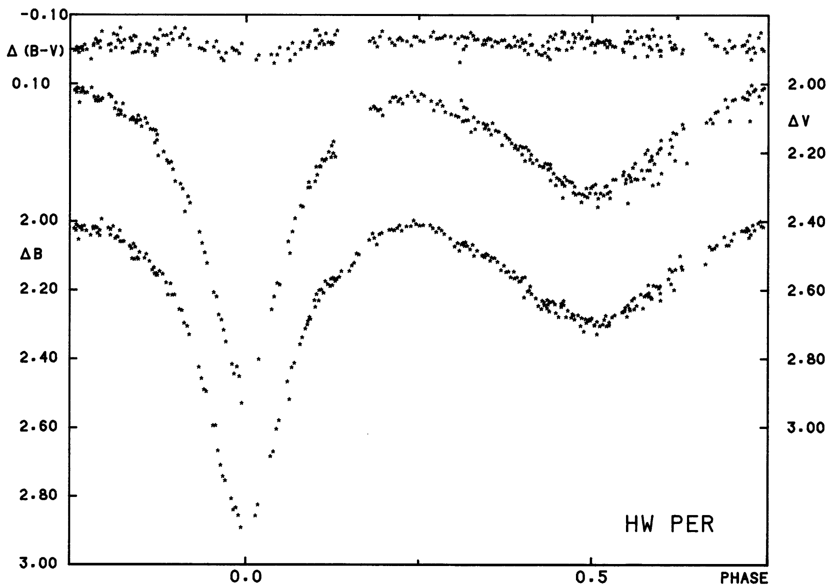

Figure 3. B, V and B−V photoelectric light and color curves as defined by the individual observations

From all available timings we calculated the improved ephemeris,

$$\text{JD Hel. Min. I} = 2450097.7838(26) + 0^{\text{d}}.63482861(18) \times E. \qquad (2)$$

Weightings for the shallow secondary eclipse timings were given a smaller value. O−C residuals calculated from Equation (2) are shown in Figure 2. The period appears to have remained fairly constant over the past sixty years.

The BV light curves and the B−V color curve as defined by the individual observations are shown as Figure 3 as differential magnitude (V−C), versus phase. Modern synthetic light curve calculations reveal that both shallow contact solutions with fillouts of $< 5\%$ and semi-detached solutions with secondary fillouts $< 5\%$ fit the observations quite well. The large temperature difference in components, T1$\sim$7600, T2$\sim$4800, would seem to preclude contact.

RM did a much of the preliminary work on this system in the Summer and Fall of 1996 as a part of research sponsored by the American Astronomical Society REU program.

This research was partially supported by funds from the National Science Foundation.

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NEW LIGHT CURVES AND PERIOD STUDY OF THE CONTACT BINARY W URSAE MAJORIS

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W Ursae Majoris (HD 83950, BD+56°1400, F8V+F8V) is a well known eclipsing variable and serves as the prototype for W UMa-type contact binaries. Recent observations of this famous star were conducted at the Villanova Observatory by T. Anselowitz, R. Mittal, M. Sauer, and R. Slevinsky on the nights of April 2, 3, 5, 15, and 16 UT, 1997. A 38 cm Cassegrain reflector equipped with a photoelectric photometer and a refrigerated EMI 9658 photocell were used. Over 300 observations were secured in intermediate-band H_αw (λ_{max} = 6600Å, FWHM = 272Å) and Strömgren y (λ_{max} = 5500Å, FWHM = 250Å) filters. The observation sequence used was the usual *sky-comp.-variable-comp.-sky* routine with an integration time of 20 seconds for each observation. HD 83728 (K2, $m_v = +9.2$) served as the comparison star. Corrections for differential extinction were applied but were always very small because of the close proximity of the comparison and variable stars.

The compiled light curves for both filters are shown in Figure 1. The primary eclipse is about 0.03 mag fainter than the secondary in both bandpasses. Also, the maximum at 0.25 phase is about 0.02 mag brighter in each bandpass than the corresponding maximum at 0.75 phase. The presence of starspots as described by Guinan & Bradstreet (1988) is the likely cause for these asymmetries in the light curve. A representative model using system elements from Maceroni & van't Veer (1996) and Bradstreet's *Binary Maker 2.0* program (1993) is shown above the observed light curves. Times of secondary minimum were obtained on the nights of April 5 and 16 UT, 1997. The moments of minimum were calculated using the method of Kwee & van Woerden (1956) for both the H_αw and y filters, yielding averaged secondary minimum timings of Min II = HJD 2450543.5667 and Min II = HJD 2450554.5776 for the two nights.

The above photometry of W UMa represents only the most recent data taken of this star at Villanova. W UMa has been observed from the Villanova Observatory since 1982. Times of minimum for these observations are presented for the first time in Table 1. The large number of eclipse timings provide an important opportunity to study the system's dynamical evolution over the last decade and a half. Figure 2 shows the observed minus computed (O−C) values of the Villanova data (solid circles) along with other primary minimum timings found in the IBVS (open circles) since 1982. An ephemeris of

$$JD\ Hel.\ Min.\ I = 2444986.3624 + 0.33363808\ \times\ E \qquad (1)$$

taken from Hamzaoglu *et al.* (1982) was used in calculating the (O−C)'s.

Table 1: Times of Minimum, March 1982 to March 1995

Filter	Type	JD Hel. (+2440000)	Observer	Filter	Type	JD Hel. (+2440000)	Observer
y	I	5042.7469	R. Donahue	H_αw	II	8311.5459	K. Miller
y	I	5407.7463	D. Speranzini	y	II	8311.5448	"
y	II	5407.9145	"	H_αw	I	9013.6793	B. Abbott
H_αw	I	5753.7242	C. Robinson	y	I	9013.6785	"
y	I	6131.7368	J. Buckley	H_αw	II	9017.8517	"
H_αw	I	6521.7569	S. Carroll	y	II	9017.8511	"
y	I	6521.7590	"	H_αw	I	9021.6850	D. Griffith
H_αw	I	6851.7228	E. Bergin	y	I	9021.6860	"
H_αw	II	6851.8886	"	H_αw	I	9398.6945	T. Mahler
y	I	6851.7218	"	H_αw	I	9399.6955	"
y	II	6851.8887	"	H_αw	II	9402.8660	"
H_αw	I	7558.6958	C. Baluta	y	II	9402.8658	"
y	I	7558.6967	"	H_αw	I	9423.7183	J. Marshall
y	I	7602.7357	L. Ilaria	y	I	9423.7178	"
H_αw	I	7602.7353	"	H_αw	I	9465.7523	J. Maley
H_αw	II	7608.5743	"	y	I	9465.7536	"
y	II	7608.5741	"	y	II	9475.5999	Q. Nguyen
H_αw	II	7990.5871	T. Thrash	H_αw	II	9478.6011	M. Alexander
y	II	7990.5876	"	y	II	9478.6016	"
H_αw	I	8296.6971	K. Miller	Bn	II	9789.5462	N. Morgan
y	I	8296.6967	"	Bn	I	9789.7144	"

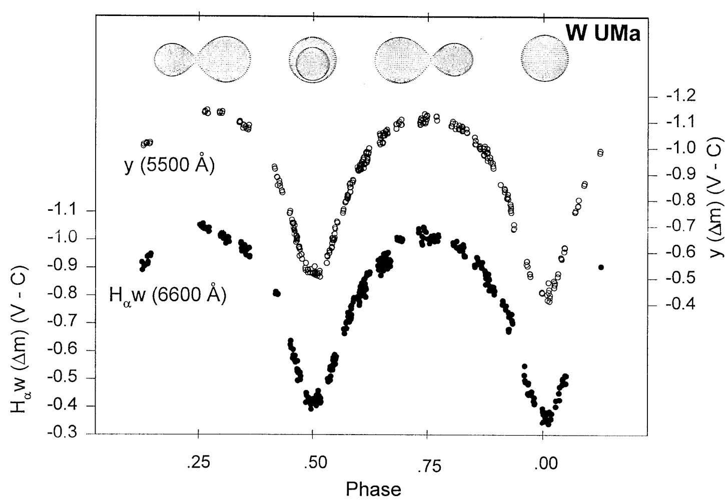

Figure 1. Strömgren y and intermediate band H_αw light curves of W UMa, obtained on the nights of April 2, 3, 4, 5, 15, and 16 UT, 1997. The representative model at top was made using *Binary Maker 2.0* (Bradstreet 1993). Phases were computed using Eq. 1.

Figure 2 shows both a quadratic (dotted line) and linear (solid line) least squares fit to the (O−C) data obtained between 1982 and 1997. The quadratic (parabolic) fit exhibits a slight negative concavity, indicating that the period of W UMa may have continuously decreased during this time interval. This deviation from a linear fit, however, is very small and may not be physically meaningful. The linear fit to the (O−C) data assumes a constant period over the time interval. The slope of the linear regression (-0.0254×10^{-4} days) represents the change in the system's period as given in Eq. 1 required to eliminate (O−C) residuals along the linear fit. Correcting the $P_1 = 0\overset{d}{.}33363808$ period from Hamzaoglu *et al.*, the system's new observed period becomes $P_2 = 0\overset{d}{.}33363554$. This apparent change in period corresponds to a shortening of the period by 0.22 seconds.

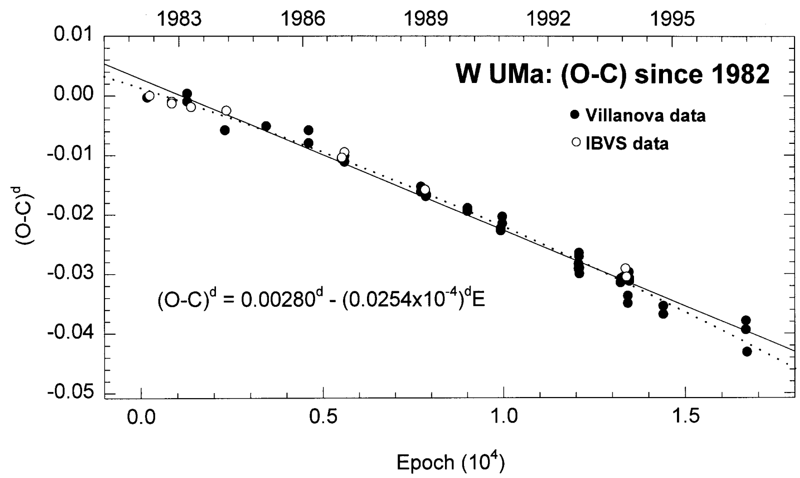

Figure 2. (O−C) analysis for W UMa from 1982 through 1997. The parabolic fit (dotted line) shows a slight negative concavity. The displayed equation describes the linear (solid line) least-squares fit to the (O−C) residuals.

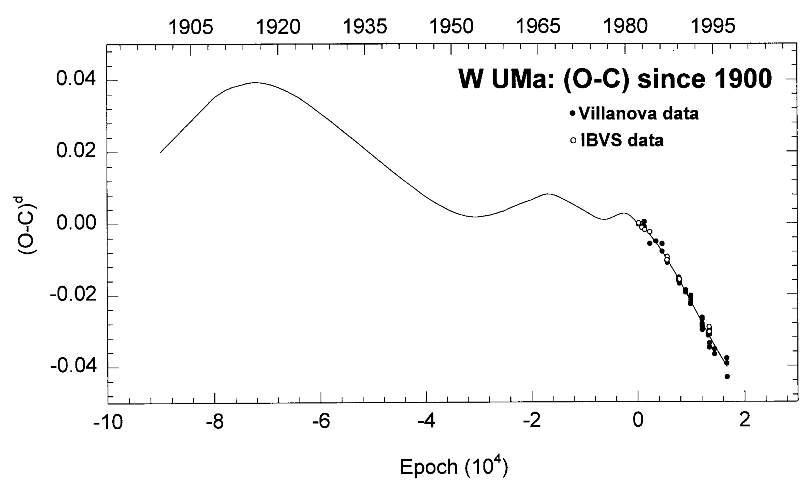

Figure 3. (O−C) analysis for W UMa from 1903 through 1997. The curve prior to 1982 is reproduced from Hamzaoglu *et al.* (1982). It is evident from the overall behavior of the (O−C) values that W UMa has undergone a series of period changes throughout this century.

When combined with the eclipse timings presented above, a new working ephemeris of

$$JD\ Hel.\ Min.\ I = 2450554.7444 + 0.33363554 \ \times \ E \tag{2}$$

can be presented for the system. This linear ephemeris should be accurate enough to predict eclipse timings for the next few years.

A complete set of visual and photometric data on W UMa has been available since its discovery by Müller & Kempf (1903). Hamzaoglu *et al.* (1982) have published a period study of W UMa that covered over three quarters of a century, stretching from 1903 through 1982. In Figure 3, we extend their (O−C) plot from 1982 up to the present continuing to use the ephemeris of Eq. 1. The section of the curve without data points is reproduced from Hamzaoglu *et al.* (1982). Villanova timings (solid circles) and other minimum timings presented in the IBVS (open circles) are shown.

Based on Figure 3, W UMa has apparently undergone a series of significant period changes since 1903. Exactly when these period changes took place, however, is uncertain because of the sometimes ambiguous nature of (O−C) analysis. The (O−C) curve can be viewed as a series of parabolas of alternating concavity (*i.e.*, epochs of continuous increases or decreases in period) or it can be viewed as a series of straight lines with alternating slopes (*i.e.*, abrupt changes in the apparent period). Each interpretation yields different times and rates of mass transfer/loss and magnetic breaking effects. The uncertainties in eclipse timings make it difficult to decide which interpretation is physically correct.

Regardless of when these period changes occurred, there still remains the question of how. One of the more attractive explanations to describe this phenomenon is of mass transfer between the components of the system, causing period changes on the basis of angular momentum redistribution. A favored mechanism to drive the mass flows comes from activity-related phenomena, whose characteristic time-scales match the relatively rapid period changes evidenced in W UMa-type systems (Rucinski 1993). Guinan & Bradstreet (1988) argue that the presence of large starspots, as betrayed from light curve asymmetries, as well as the strong chromospheric and coronal X-ray emissions typical of W UMa-type binaries, indicate the presence of a strong, dynamo-related magnetic activity for the system. These intense magnetic fields may very well control the mass flows and magnetic breaking effects responsible for the observed period changes.

Further photoelectric photometry of W UMa will continue at the Villanova Observatory. For this research, we utilized the SIMBAD database, operated by CDS, Strasbourg, France. This research was supported in part by NSF grant AST-9315365, which we gratefully acknowledge.

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HAS THE δ SCUTI STAR BS Aqr A COMPANION?

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The light variation of BS Aqr was discovered by Hoffmeister (1931). Since then, BS Aqr has been observed by many authors and become one of the 19 δ Scuti stars which have reasonable long-time span observations for us to calculate their reliable period change rates (Jiang 1993). Yang et al. (1993) collected 48 times of light maximum for this star in the literature and provided a new one determined by themselves.

We observed BS Aqr on December 20, 1995 in Xinglong station of Beijing Astronomical Observatory with a 60 cm telescope and its CCD camera. One new moment of light maximum was derived and then all the times are listed in Table 1 with 50 data points over more than six decades.

With the times of light maxima of BS Aqr which are listed in Table 1, the linear fit is used to determine the calculated light maxima by the formula of $C_l = T_{01} + P_{01}E$. The results of fitting are: T_{01} = HJD2428095.3346, $P_{01} = 0.197822612$ days. The values of $(\mathrm{O-C})_l$ are also listed in Table 1. The residual obtained (σ_{01}) is 0.0043 days. Then the quadratic curve is used to fit the data as: $C_Q = T_{02} + P_{02}E + 0.5\beta_{01}E^2$. The fitting parameters are: T_{02} = HJD2428095.3319, $P_{02} = 0.197822744$ days, $\beta_{01} = -1.2 \times 10^{-12}$ days/cycle, with the residual (σ_{02}) of 0.0044 days. The $(\mathrm{O-C})_l$ diagram and the fit curve using the quadratic function are shown in Figure 1 (a).

From this figure, one may find that the fit is not good, and the differences between the points and the curve may imply another intrinsic periodic variation. Thus, the formula of $C_{orb} = T_{03} + P_{03}E + 0.5\beta_{02}E^2 + A\sin\phi + B\cos\phi$ is used to fit the original times of light maxima, where ϕ is the solution of $\phi - e\sin\phi = 2\pi f(P_{03}E - \tau)$. The related parameters are determined as: T_{03} = HJD2428095.3320, $P_{03} = 0.197822675$ days, $\beta_{02} = -0.5 \times 10^{-12}$ days/cycle, $A = -0.0040$ days, $B = 0.0001$ days, $P_{orb} = 34.05$ years, $e = 0.5$, and $\sigma_{03} = 0.0036$ days. The O−C diagram and the fit curve using both the quadratic and the trigonometric functions are shown in Figure 1 (b).

From Figure 1 and the comparison of the residuals after different fits, one may find that the model of explaining the discrepancies between the observed and calculated times of maximum light as the consequence of a continuously changing (decreasing) period, combined with the light-time effect caused by the orbital motion of BS Aqr around the mass center of a binary system with an unseen companion, is reasonable.

Based on the coefficients provided by the fitting, some additional parameters of the binary system of BS Aqr can be estimated. The projection of the orbit radius: $a_1 \sin i \approx$ $\approx$ 0.699 AU; the mean velocity of the primary star projecting on the orbit: $K \approx$ $\approx$ 0.61 km s^{-1}; the mass function: $f(m) \approx 0.00029$. Under the values of the mass and the radius of BS Aqr: $M_1 = 1.89 M_\odot$, $R_1 = 4.04 R_\odot$ (McNamara & Feltz 1978), the semi-major axis of the orbit and the mass of the companion are derived with different inclination angles and the result is listed in Table 2.

Obviously, more observations are needed to check the binary hypothesis for BS Aqr. However, since the calculated orbital radial velocity amplitude (K) is very small, the spectroscopic measurements might not be very helpful to confirm the binary model for BS Aqr.

There is an interesting possibility to determine the pulsation constant (Jørgensen & Grønbech, 1978). Combining Kepler's third law and the pulsation constant formula,

$$\frac{a^3}{P_{orb}^2} = \frac{G}{4\pi^2}(M_1 + M_2), \quad \text{and} \quad Q = P_{pul}\left(\frac{M_1}{R_1^3}\right)^{1/2}$$

we obtain

$$Q = 0.1159 \frac{P_{pul}}{P_{orb}} \left(\frac{R_1}{a}\right)^{-3/2} \left(1 + \frac{M_2}{M_1}\right)^{-1/2}$$

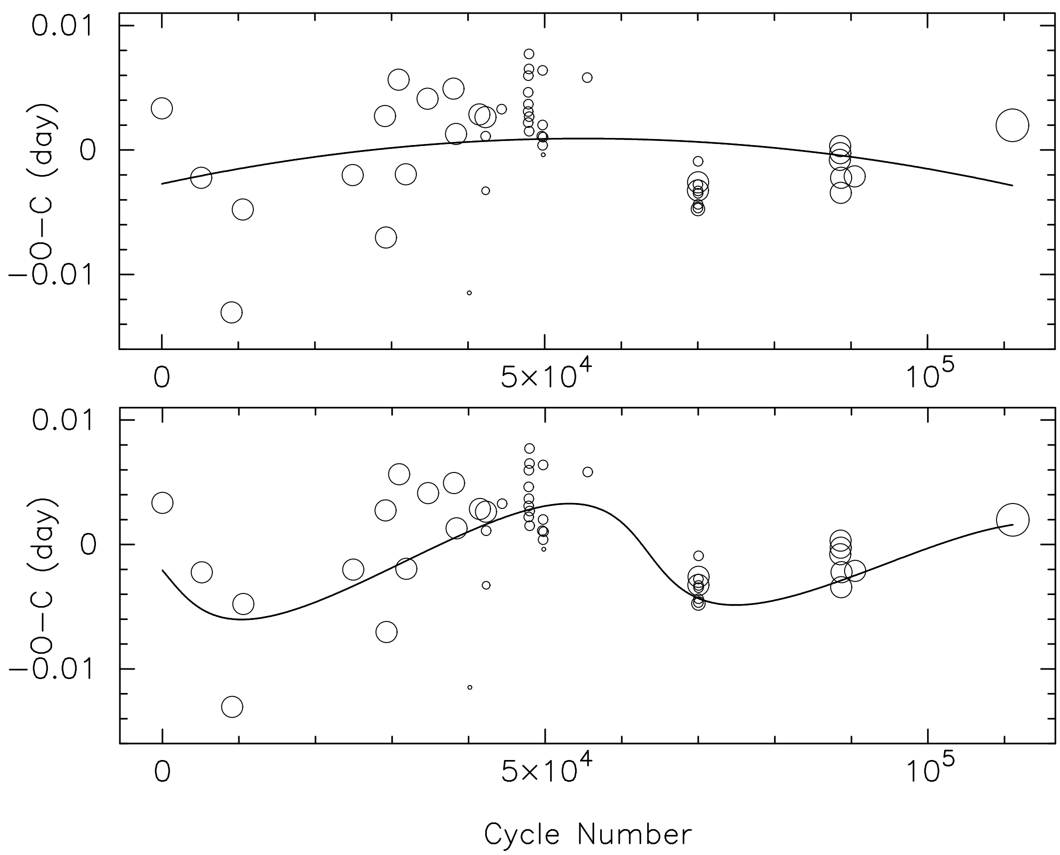

Figure 1. The O−C diagrams and the fit curves by using (a) the quadratic function, and (b) both the quadratic and the trigonometric functions for BS Aqr

Table 1: Times of light maxima of BS Aqr

No.	HJD (2400000.0+)	E	(O-C)$_l$ (day)	W	Ref.	No.	HJD (2400000.0+)	E	(O-C)$_l$ (day)	W	Ref.
1	28095.3380	0.0	0.0033	1.0	An	26	37584.2934	47967.0	0.0015	0.5	TS
2	29111.7450	5138.0	−0.0022	1.0	As	27	37584.4924	47968.0	0.0027	0.5	TS
3	29899.2660	9119.0	−0.0131	1.0	Sa	28	37911.4916	49621.0	0.0011	0.5	TS
4	30187.3040	10575.0	−0.0048	1.0	Sa	29	37932.4617	49727.0	0.0020	0.5	TS
5	33027.4460	24932.0	−0.0020	1.0	Sa	30	37933.4552	49732.0	0.0064	0.5	TS
6	33862.4600	29153.0	0.0027	1.0	Sa	31	37934.4383	49737.0	0.0004	0.5	TS
7	33888.3650	29284.0	−0.0070	1.0	Sa	32	37946.3083	49797.0	0.0010	0.5	TS
8	34211.4220	30917.0	0.0056	1.0	Sa	33	37947.2960	49802.0	−0.0004	0.1	TS
9	34400.3350	31872.0	−0.0019	1.0	Sa	34	39087.1561	55564.0	0.0058	0.5	HP
10	34961.3660	34708.0	0.0041	1.0	Sa	35	41946.6714	70019.0	−0.0047	0.6	El
11	35631.3920	38095.0	0.0049	1.0	Sa	36	41946.8693	70020.0	−0.0047	0.5	El
12	35696.4720	38424.0	0.0013	1.0	Sa	37	41947.6620	70024.0	−0.0032	1.0	El
13	36040.0771	40161.0	−0.0115	0.1	Ki	38	41947.8603	70025.0	−0.0028	0.5	El
14	36300.4260	41477.0	0.0029	1.0	Sa	39	41948.6500	70029.0	−0.0044	0.5	El
15	36458.0904	42274.0	0.0026	1.0	Sp	40	41948.8489	70030.0	−0.0033	0.5	El
16	36460.8540	42288.0	−0.0033	0.3	Sp	41	41949.6400	70034.0	−0.0035	0.5	El
17	36461.8475	42293.0	0.0011	0.5	Sp	42	41950.6300	70039.0	−0.0026	1.0	El
18	36874.1120	44377.0	0.0033	0.5	Ki	43	41950.8295	70040.0	−0.0009	0.5	El
19	37561.3491	47851.0	0.0046	0.5	TS	44	45612.7240	88551.0	−0.0008	1.0	Me
20	37561.5445	47852.0	0.0022	0.5	TS	45	45620.6380	88591.0	0.0003	1.0	Me
21	37562.5345	47857.0	0.0031	0.5	TS	46	45625.5830	88616.0	−0.0003	1.0	Me
22	37563.5242	47862.0	0.0037	0.5	TS	47	45637.6470	88677.0	−0.0034	1.0	Me
23	37564.5156	47867.0	0.0060	0.5	TS	48	45644.5720	88712.0	−0.0022	1.0	Me
24	37582.5180	47958.0	0.0065	0.5	TS	49	45997.0920	90494.0	−0.0021	1.0	Ya
25	37583.3105	47962.0	0.0077	0.5	TS	50	50072.0441	111093.0	0.0020	1.5	pp

*An:	Andrews (1936)	*pp:	present paper
*As:	Ashbrook (1943)	*Sa:	Satanova (1961)
*El:	Elst (1976)	*Sp:	Spinrad (1959)
*HP:	Harding and Penston (1966)	*TS:	Tremko and Sajtak (1964)
*Ki:	Kinman (1961)	*Ya:	Yang et al. (1993)
*Me:	Meylan et al. (1986)		

Table 2: Inclination, semi-major axis of the orbit and mass of the companion of BS Aqr

i(deg)	a(AU)	$M_2(M_\odot)$
10	14.74	0.726
20	13.70	0.330
30	13.47	0.218
40	13.36	0.167
50	13.30	0.139
60	13.26	0.122
70	13.24	0.112
80	13.23	0.107
90	13.22	0.105

Adopting $P_{pul} = 0.197822675$ days, $P_{orb} = 12436$ days, $M_1 = 1.89M_\odot$, $R_1 = 4.04R_\odot$, $a = 13.5$ AU (see Table 2), and $M_2 = 0.105 \sim 0.330M_\odot$ (the value of $0.726M_\odot$ is too big, due to the fact that we have not seen its light), the pulsation constant is calculated: $Q \approx 0.034$. This value corresponds to the radial fundamental mode (e.g. Petersen and Jørgensen 1972).

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THE DROP IN BRIGHTNESS OF MWC 560≡V694 Mon

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MWC 560 is a symbiotic-like variable demonstrating a large variety of changes in its brightness and spectrum. The system consists of an M4.5 giant and a white dwarf – probably magnetic. The time scale of the observed variations in the star brightness ranges from minutes to years. In the optical, the spectrum of the star is dominated by a hot continuum corresponding to a late B star. A forest of emission lines, mainly of HI and singly ionized metals, with constant radial velocity and relatively small variations in the intensity is always present. The most amazing spectral features are the intense and variable absorption components, mainly of the Balmer lines, appearing with blue-shifts reaching several thousands km s^{-1} (see for details Tomov et al. 1996; Tomov & Kolev 1997, and references therein).

After the highest (V$\sim$9^{m}) maximum ever observed in 1990, the MWC 560 brightness decreased by about 1^{m} until 1993 (Fig. 1). Then for several years the star brightness showed variations reaching an amplitude of about $0\overset{m}{.}5$ around a mean value V$\sim$$10\overset{m}{.}2$. A not so prominent maximum, best visible in the visual light curve in Fig. 1, appeared in 1995. The time interval between the 1990 and 1995 maxima well agrees with the proposed orbital period $\sim$1930^{d} (Doroshenko et al. 1993).

During the first months of 1997 a systematic decrease in the visual brightness of MWC 560 began (Fig. 1). A noteworthy drop in magnitude of MWC 560 occurred in April 1997. The magnitudes obtained on April 23 and 26 in comparison to March 23 indicate the amplitudes of drops about $1\overset{m}{.}5$, $0\overset{m}{.}9$, $0\overset{m}{.}7$, $0\overset{m}{.}3$ in U, B, V, R, respectively, and possibly about $0\overset{m}{.}1$–$0\overset{m}{.}15$ in I. The visual estimates in April show the lowest values since 1990 as well. Unfortunately, in May the star became invisible in our observatories. First visual estimations obtained in July–August confirm the existence of the drop.

As it can be seen in Fig. 1, during all the period 1990–1997 the brightness of the star varies in a very similar way in the UBVR bands with an amplitude strongly decreasing from U to R. The character of the changes is different in I band only. This indicates that the hot continuum remarkably contributes to the brightness of MWC 560 up to the wavelengths covered by the R filter and that in the I band the flux from the M giant dominates. Therefore, the observed drop in the brightness, most probably is caused by a phenomenal decrease in the flux of the hot continuum source.

The spectroscopic monitoring of MWC 560 showed slightly increasing activity at the beginning of the last observing season in September 1996 (Georgiev et al. 1996). Examples of the changes in the absorption lines of HI, HeI, HeII and FeII between September 16 and 19 are shown in Fig. 2. The spectra were obtained by the echelle spectrograph of the 2.1 m telescope, OAN San Pedro Martir (Mexico) – spectral range 3700–7000 Å, resolution about 0.4 Å and S/N ratio changing between 50 and 100 over the spectral range.

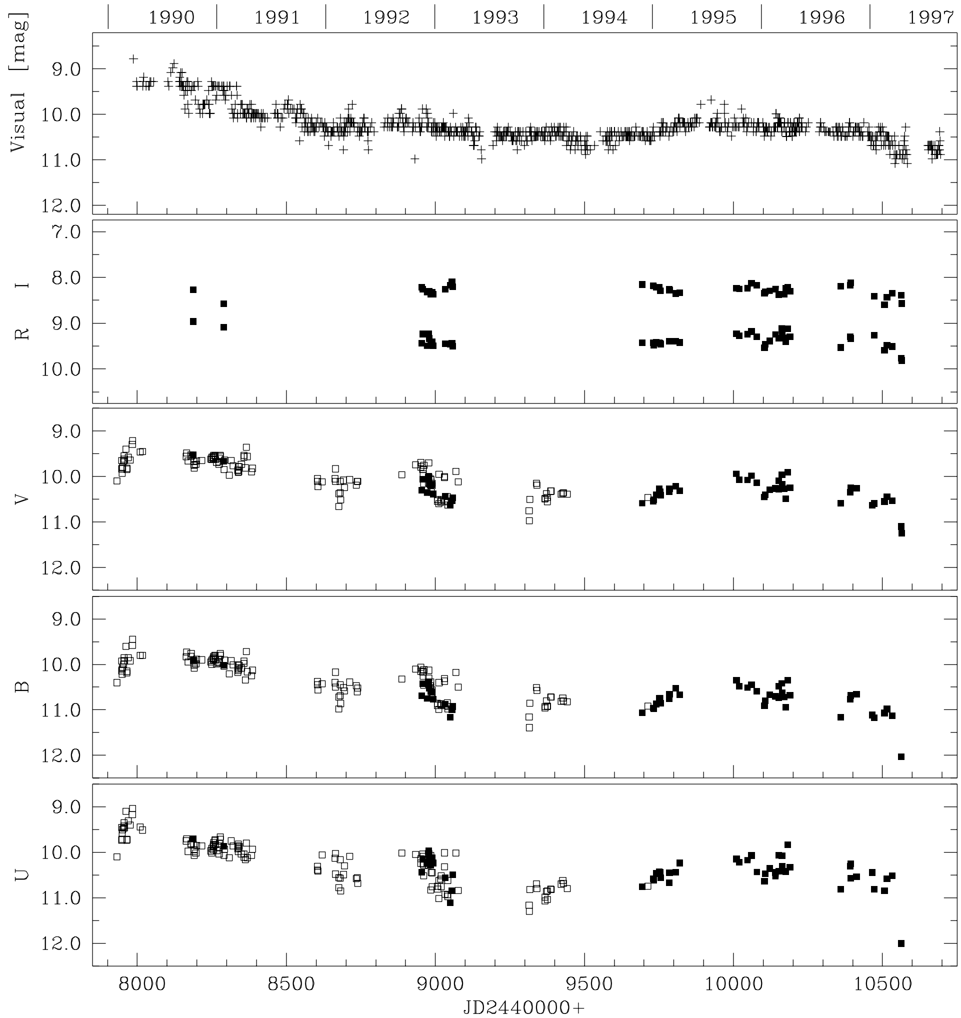

Figure 1. UBVRI and visual light curves of MWC 560. The data from Tomov et al. (1996) (*squares*) are combined with new UBVRI observations from Torun (Poland), new UBV observations from Rozhen (Bulgaria) (*filled squares*) and new visual estimates by A.J. (New Zealand). Description of the equipment and the accuracy of the observations can be find in Tomov et al. (1996). The visual magnitudes are corrected with $-0\overset{m}{.}22$ as in Tomov et al. (1996).

The Balmer absorptions appeared with a strongly variable multicomponent structure. The blue wings of these absorptions (Hγ in Fig. 2) are extended to about $-2000\,\mathrm{km\,s^{-1}}$ on September 16 and to more than $-3000\,\mathrm{km\,s^{-1}}$ on September 19. The intensity of the slowest absorption component, with a velocity of the order of -600 to $-700\,\mathrm{km\,s^{-1}}$, remarkably decreases in four days. A relatively strong absorption of FeII 5169 Å is present on September 16 at $\sim -1400\,\mathrm{km\,s^{-1}}$. The intensity of this feature gradually decreases, simultaneously with strong variations in its shape, and in the spectrum on September 19 a much fainter, clearly double component ($\sim -1500\,\mathrm{km\,s^{-1}}$ and $\sim -2000\,\mathrm{km\,s^{-1}}$) can be seen. The HeI 4471 Å line behaves differently. On September 16 this absorption is weak and because of the blending with the emissions it is difficult to say something about its shape. On the September 17, 18 and 19 spectra a relatively intense absorption component of this line can be seen, changing in shape and with slightly increasing blue-shift (reaching about $-2200\,\mathrm{km\,s^{-1}}$ on September 19). On the spectra of the last two dates an additional, much weaker and slower ($\sim -500\,\mathrm{km\,s^{-1}}$ — $-600\,\mathrm{km\,s^{-1}}$) absorption component of HeI 4471 Å appeared in the spectrum of MWC 560.

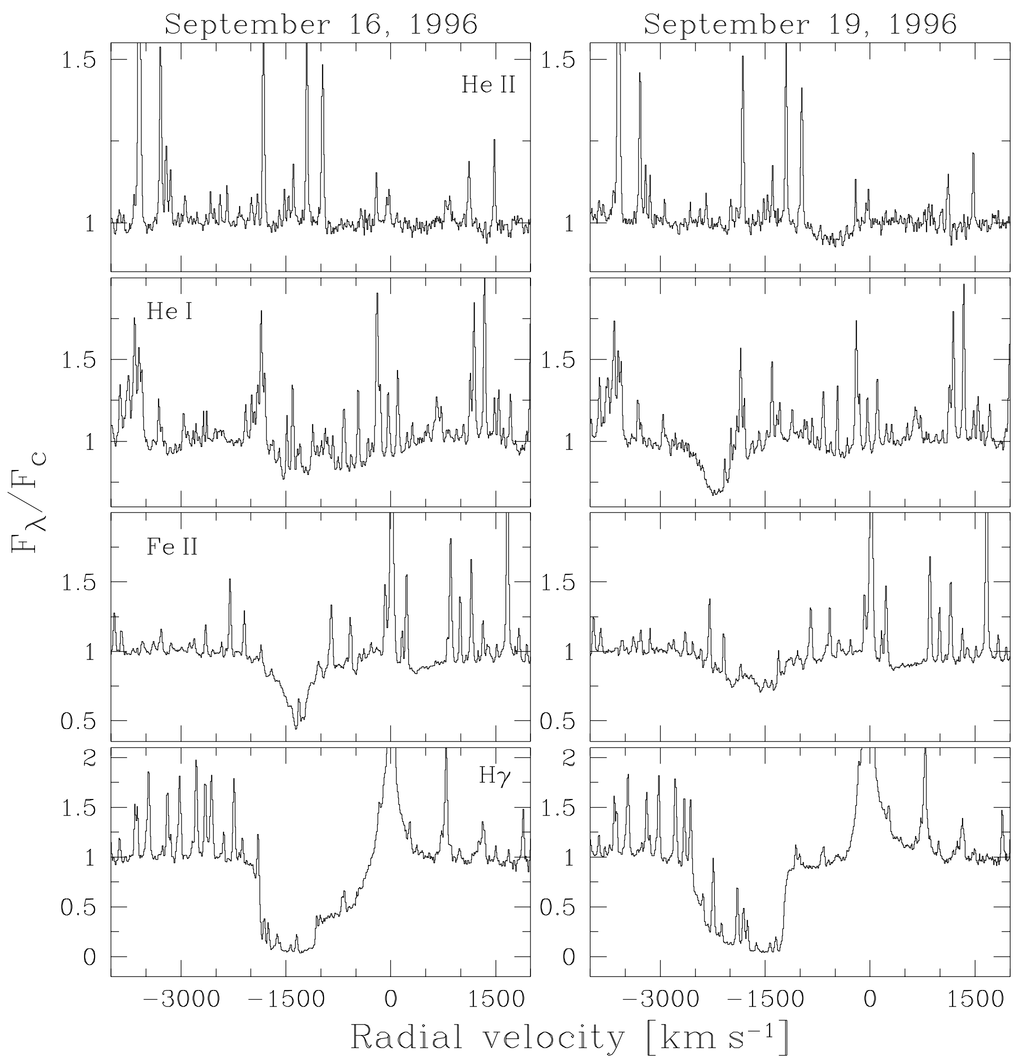

Figure 2. The absorption components of the HeII 4686 Å, HeI 4471 Å, FeII 5169 Å and Hγ lines in the spectrum of MWC 560 observed on September 16 and 19, 1996. The spectra are normalized to the local continuum level. The strongest emission peaks are truncated for plot clarity.

The most intriguing feature is the appearance of a very weak HeII 4686 Å absorption line in the spectrum of MWC 560. It is absent on September 16 and is best visible on September 19. The blue-shift of this line is $\sim -500\,\mathrm{km\,s^{-1}}$ — $-600\,\mathrm{km\,s^{-1}}$, i.e. very close to the velocities of the slowest Hγ and HeI 4471 Å absorption components. The presence of the high excitation lines (as HeII) in the MWC 560 spectrum has not been mentioned before in the literature. An inspection of our old CCD and photographic spectra show that this line was not visible even during the highest activity in 1990 and only a faint absorption line probably appeared in the spectrum in November 1994.

Mikołajewski et al. (1996, 1997) have argued that MWC 560 and CH Cygni may be the prototypes of new subclass of symbiotic binaries deriving energy of the hot component from the stellar wind accretion and the fast rotation of a magnetic white dwarf. The most prominent episode in CH Cyg was a drop in hot continuum observed in July 1984, accompanied by the radio outburst and jets' ejection (Taylor et al. 1985), X-ray emission (Leahy & Taylor 1987), the appearance of wide (up to $\pm 1500\,\mathrm{km\,s^{-1}}$) wings in the Balmer emission lines (Mikołajewski &Tomov 1986) and the broad He II 4686 emission line (Leedjärv et al. 1994). In the oblique rotator model of CH Cyg (Mikołajewski et al. 1990a,b) the drop in July 1984 was interpreted as a transition between *accretor* and *propeller* state of the magnetosphere.

From the historical light curve of MWC 560 (Luthardt 1991) it can be seen that most often the star varies between 12^{m} and 11^{m} in the m_{pg}/B brightness. Only during 1943–1953, and possibly in 1960 and in 1970–1972 has it reached reasonably flat minima with $m_{pg} \approx 12\overset{\mathrm{m}}{.}5$. In 1990 MWC 560 has reached maximum, $B \approx 9\overset{\mathrm{m}}{.}4$ followed by a gradual decrease until March 1997 and $B \approx 11^{\mathrm{m}}$. On the basis of the resemblance between MWC 560 and CH Cyg we can suppose that the drop in the brightness of MWC 560 observed recently may indicate a similar *accretor* $\Rightarrow$ *propeller* transition. In case this is true, any optical and especially X-ray and radio observations would be very valuable.

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AC Vel, A TRIPLE SYSTEM. A CALL FOR OBSERVATIONS OF MINIMA AND SPECTRA

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AC Vel (SAO 238458, HD 93468, $(\alpha,\ \delta)_{2000} = 10^{\rm h}46^{\rm m}18\overset{\rm s}{.}40,\ -56^\circ49'45\overset{\prime\prime}{.}4$) is a binary consisting of two eclipsing early B type stars plus at least one more star. Complete light curves were obtained in the Strömgren *uvby* photometric system in 1982–1984. Additional times of minima have been observed between 1985 and 1997. Radial velocities have been measured by J. Andersen in 1984–86 and by P.F.L. Maxted in 1996 (both unpublished).

The photometric data provide a period P for the eclipses near 4.5622 days and indicate a circular orbit. The primary minimum has a depth of $0\overset{\rm m}{.}45$ in y, the secondary is $0\overset{\rm m}{.}40$ deep. Figure 1 shows the y light curve (Helt et al. 1998). From the spectroscopic and photometric analyses we obtain a preliminary value for the mass sum of $14 \pm 1.5 M_\odot$ and a mass ratio of 1.00 ± 0.05. Preliminary determination with the WINK code (Wood 1971, 1972, Vaz et al. 1995) of orbital inclination and radii indicates that the stars have evolved to the TAMS region. They should thus be useful for an empirical test of convection prescriptions. The presence of third light is indicated by the analysis. It amounts to 10–15% of the total light in y, enough to be obvious in the photometric solution but insignificant enough to make the lines of the third star inconspicuous in the spectra.

We soon noticed that the period of AC Vel is variable. This is not surprising since light time effect is to be expected in a system with a considerable amount of third light. Our observed times of minima are, however, insufficient for a full analysis of the O−C residuals from a linear ephemeris and we have so far restricted our modelling to circular orbits of the eclipsing pair around the centre of gravity of the system. The data indicate a period P' for this orbit of only 15–17 years.

The variability of AC Vel was discovered by Hertzsprung (1926) who obtained 520 photographic plates covering the region of η Car. The exact interval of time for the observations is not given by Hertzsprung but most of the observations must have been made during the first 6 months of 1924. His epoch corresponds to May 1924 and his period is half the true period, 2.28083±0.00030 days. As the precise distribution of Hertzsprung's observations is unknown but the time interval short compared to the period P' we have simply used his epoch (HJD 2423934.011 ± 0.017) as the time of a secondary minimum.

Gaposchkin also studied AC Vel and noticed that the period was twice Hertzsprung's value (Gaposchkin 1946, 1953). His epoch and period (HJD 2429342.594, 4.5622426 days) are based on 990 photographic plates, partly Harvard Patrol plates that may date back at least as far as 1896, partly plates from the period 1938–1947. This wide time span turns out to be much larger than the period P'. For that reason we cannot use his ephemeris in our determination of the most likely P'.

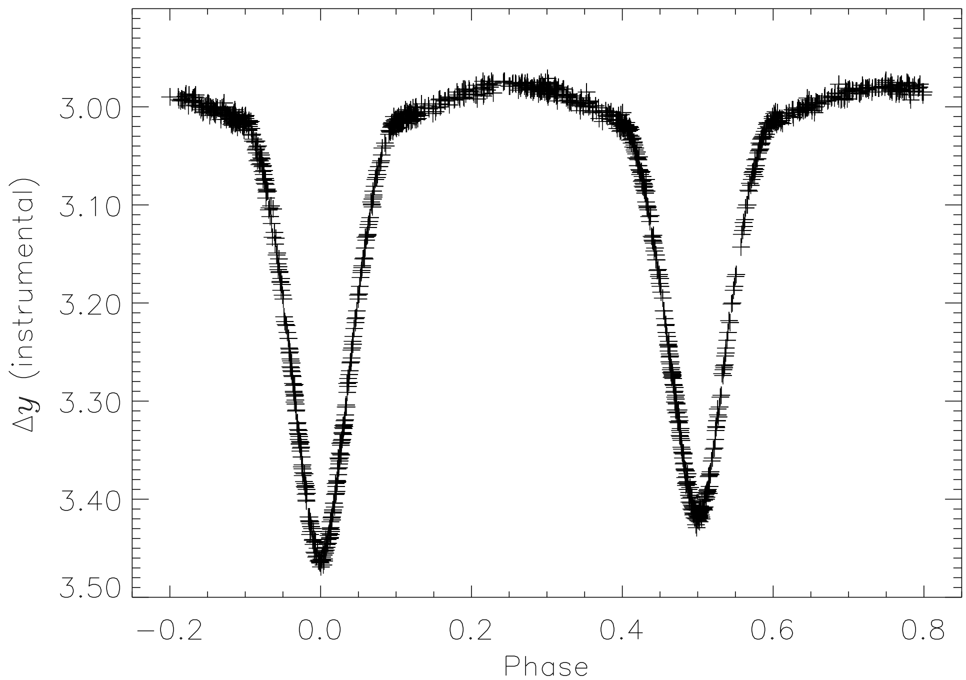

Figure 1. The differential y light curve: AC Vel – HR 4239AB

Our times of minima are given in Table 1. They were determined with the Kwee and van Woerden (1956) method even though there is a slight indication of asymmetry in the secondary minimum. For that reason we also provide the beginning and end of the time interval ΔT used for determination of the time of minimum. The O−C values are calculated as residuals from a linear ephemeris with period P_{true}, the true period for the orbital motion that causes the eclipses of stars A and B (value determined below). The large O−C values reflect the orbital motion of the AB pair around the common center of mass of AB and the third star.

We have attempted to find permitted values of P'. The shape of the orbit of the AB pair around the center of mass is unknown and may well be eccentric. As we have so far only ten times of minima not uniformly distributed in time we are unable to determine e and ω for an eccentric orbit, and we have assumed that the orbit is circular.

From Hertzsprung's minimum combined with our latest minimum we can restrict the permitted values for the true period P_{true} to small time intervals, each corresponding to a certain number of periods elapsed between the two minima. The one that gives the smallest values of O−C has $\Delta E = 5823$ and $P_{true} = 4.56221 \pm 0.00003$ days.

Another constraint can be placed on the true period by using Kepler's third law together with sensible guesses for the mass of the third star. For each guess of ΔE we can calculate an upper and a lower limit to the orbital velocity. It turns out that a consistent solution can be found only for $\Delta E = 5823$.

Table 1: Our observed times of minima

HJD – 2400000	E	ΔT	O$-$C
45371.8090 $\pm$ 14	-90.5	.75434–.86343	0.0027
45387.7738 $\pm$ 21	-87	.71538–.83251	-0.0003
45784.6771 $\pm$ 2	0	.51402–.84262	-0.0095
45816.6132 $\pm$ 5	7	.49101–.73870	-0.0089
46149.6467 $\pm$ 4	80	.51803–.78462	-0.0169
46831.6848 $\pm$ 4	229.5	.56176–.80963	-0.0297
50134.7860 $\pm$ 4	953.5	.67258–.89872	0.0293
50141.6311 $\pm$ 5	955	.52440–.73433	0.0311
50490.6382 $\pm$ 4	1031.5	.53565–.74610	0.0289
50499.7620 $\pm$ 4	1033.5	.62175–.89899	0.0282

The SBOP code (Etzel 1985) is then used to fit a circular orbit to the O$-$C values for a range of values of P_{true} around 4.56221. The formula used by SBOP is

$$\mathrm{O}-\mathrm{C} = a_{AB} \times \sin i \times \cos(2\pi(t-T)/P') + V_o \tag{1}$$

where T is the time of maximum O$-$C, that is the time when the AB pair is farthest off. For each assumed value of P_{true} we thus find P', T, an amplitude $a_{AB} \times \sin i$ that represents the radius in light days of the AB pair's orbit around the center of mass times $\sin i$, and a zero point, V_o. This permits prediction of the observed period P_{app} for a given time interval. If Hertzsprung's point is given weight 0 and our ten points are weighted according to their Kwee and van Woerden (1956) standard errors we find minimum standard deviation for $P_{true} = 4.562232$. This value would imply that Hertzsprung's point is off by 0.15 days.

We have also determined the observed apparent period P_{app} for the time interval of light curve observations. For our 1983-84 data that cover all essential phases of the light curve we have used the Lafler–Kinman (1965) method (program kindly provided by L.P.R. Vaz) to find $P_{app} = 4.562118 \pm 0.000007$. The value for P_{true} that predicts this P_{app} is 4.562233 ± 0.000003.

Our *uvby* data predict $P_{true} = 4.562232$ which leads to $P' = 15.1$ years. If, however, we accept that Hertzsprung's data cannot be off by more than $2\,\sigma$ we must adopt $P_{true} \leq 4.562213$ and the corresponding value of $P' \geq 17.2$ years. The difference probably reflects that the $\approx$16 year orbit is eccentric while we have had to restrict our modelling to circular orbits.

Considering the fairly small value we find for P' it should be possible to determine the orbit of the eclipsing pair AB around the center of gravity of the system within a few years. On the other hand, it is important to observe the system each year. We therefore urge southern observers to put AC Vel on their observing list. Safe predictions of future times of minima can of course not be provided but our best prediction at present for minimum I, calculated with $P_{true} = 4.562213$ is

$$M = 2445784.6866 + 4.562213 \times E \tag{2}$$

$$Min\ I = M + 0.0299\ \cos(2\pi(M - 2443908)/6295) \tag{3}$$

This model is chosen such that it gives a 2σ deviation for Hertzsprung's epoch and still a reasonable fit to our observations. The O−C values in Table 1 were calculated from equation (2).

HD 92757 ($(\alpha,\ \delta)_{2000} = 10^{\rm h}41^{\rm m}26\overset{\rm s}{.}36,\ -56°04'06\overset{''}{.}6$) and HD 92155 ($10^{\rm h}37^{\rm m}16\overset{\rm s}{.}17$, $-53°51'18\overset{''}{.}6$) have been used as comparison stars and show no sign of variability. Any of them can be recommended as comparison star.

We also urge spectroscopists to put AC Vel on their observing list. The radial velocity for the center of gravity of the AB system is predicted from our simple, circular model to vary with an amplitude of 8–9 km/s, that is, a peak-to-peak variation of 16–18 km/s.

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PHOTOMETRY OF NQ Gem: A QUIESCENT SYMBIOTIC STAR?

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HD 59643 (NQ Gem) is a bright carbon star classified as C6,2 by Keenan & Morgan (1941). Its variability was not even suspected prior to 1970, when Greene & Wing (1971) much to their surprise found hydrogen emission lines in their spectra and filling-in of both the Ca II K line and the 0–0 CN band. They pointed out similarities with the symbiotic stars CH Cyg and T CrB.

To the best of our knowledge, the only report about photometric variability of NQ Gem has been so far presented by Dzervitis et al. (1979). Their BVR photoelectric data indicate NQ Gem to be a semiregular variable with a peak-to-valley amplitude of ΔB=0.^{m}22, ΔV=0.^{m}26 and ΔI=0.^{m}20. Single epoch observations of NQ Gem by Walker (1979) give V=7.99, $V-R_{\rm C}$=+1.02 and $V-I_{\rm C}$=+1.93 mag. These colors are quite blue compared to normal carbon stars (e.g. Richer 1981). Very blue colors are known also for the well established carbon symbiotic star Draco C-1. In the photometric survey of carbon stars by Noguchi et al. (1981) NQ Gem entries at J=4.05, $J-H$=+0.72, $J-K$=+1.10 and $K-L$=+0.02 mag. They confirm the evidence from the optical of very blue colors for a carbon star and absence of detectable circumstellar dust. As opposed to the poor optical photometric monitoring, a number of IUE (35) and optical spectra of NQ Gem have been obtained in the past. Johnson et al. (1988) found in the IUE spectra the continuum and the bright emission lines to vary in time. This is similar to what is observed in the symbiotic stars EG And (M2 III) and UV Aur (C2,6) that do not reveal much of their interacting binary nature in the optical, while in the IUE spectra the presence and variability of the hot companions stand out clearly.

We have secured in 1995–97 $BVI_{\rm C}$ photographic photometry of NQ Gem with two private 0.25m f/2 Schmidt cameras from San Cristoforo (Trento) in the Italian Pre–Alps. Filter and emulsion combinations, number of plates per year and typical error of a single measurement (σ) are given in Table 1. Plates have been measured with an iris Becker microphotometer. Similar exposures on the Pleiades served to calibrate a comparison sequence around NQ Gem. In Table 1 we list only the yearly mean magnitudes in view of the small (if any) variability shown by the star over the 1995-97 period compared with the typical error of photographic photometry. Further observations at the precision achievable with photoelectric or CCD photometers are necessary in order to detect the presence of the small amplitude variability reported by Dzervitis et al. (1979). It is however clear

Table 1: NQ Gem mean magnitudes for the years 1995, 1996 and 1997. N=number of plates measured per year, σ=error of a single measurement, $\overline{mag}$=yearly average magnitudes.

band	emulsion+filter	1995			1996			1997		
		N	σ	$\overline{mag}$	N	σ	$\overline{mag}$	N	σ	$\overline{mag}$
B	103a–O + GG355	15	0.3	9.5	8	0.3	9.6	14	0.3	9.6
V	Tri X + GG14	21	0.2	7.2	13	0.2	7.2	23	0.2	7.3
I_C	IR High Speed + RG665	30	0.2	5.8	41	0.2	5.9	8	0.3	5.8

from Table 1 that NQ Gem does not show variability in excess of 0.2 mag in any band and there is no year-to-year change in the mean brightness. Therefore on pure photometric grounds NQ Gem could easily escape detection on all-sky surveys.

Symbiotic stars have been discussed as possible SN Ia progenitors. The main objection against such a scenario has been an apparently low number of symbiotics in the Galaxy compared to the observed SN Ia rate. Munari & Renzini (1992) gave arguments for a total population of $\sim 3\times 10^5$ symbiotic stars in Galaxy. One of their main points is the low discovery probability of symbiotics in the optical. For example, CH Cyg was the spectroscopic standard for the M6 III type until 1963 when it revealed its symbiotic nature entering a still ongoing outburst with all sorts of photometric and spectroscopic changes (e.g. Mikolajewski et al. 1990). EG And and UV Aur are other examples of symbiotic stars looking as fairly normal field cool giants in the optical. NQ Gem appears as another example of easy-to-miss symbiotic stars. During this long lasting quiescence, its hot component is accreting mass from the carbon giant. Greene & Wing (1971) suggested that sooner or later HD 59643 should erupt. We recommend monitoring of this apparently quiescent symbiotic star, for soon it might show major activity.

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RADII OF LOW-AMPLITUDE CEPHEIDS AND THEIR PULSATION MODE

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Low-amplitude Cepheids (DCEPS in GCVS, 1985) are a specific group of pulsating stars. In contrast to ordinary Cepheids, these stars have small light amplitudes ($0^{m}.5$ V and lower) and practically sinusoidal light curves. It is usually assumed that such stars pulsate in the first overtone, whereas ordinary Cepheids, in the fundamental tone (GCVS, 1985). Theory of stellar pulsations gives the ratio of periods of the first overtone P_1 to the fundamental tone P_0, for galactic Cepheids, equal to 0.71 (see, for instance, Alcock et al., 1995).

For 13 Cepheids (see Table 1) classified as DCEPS in the GCVS, we have long sets of precise observations of radial velocity. Our radial velocity observations were made with A. Tokovinin's correlation spectrometer in 1987–1997. The majority of these observations were included in our two catalogues (Gorynya et al., 1992, 1996b).

We used these spectroscopic data together with photoelectric data (brightnesses V and color indices $B-V$) from the Sternberg Institute database (Berdnikov, 1995) to estimate the radii of such Cepheids using a nonlinear modification of the method described by Balona (1977). Note that Balona's method is, in principle, free from any significant influence of interstellar extinction.

Star	$\log P$	$R/R_\odot$	σ_R	Pulsation mode
FN Aql	0.9768	80	12	P_1
V1162 Aql	0.7305	60	14	P_1
BY Cas	0.5080	40	10	P_1
SU Cas	0.2899	33	8	P_1
V1726 Cyg	0.6271	55	5	P_1
X Lac	0.7360	61	7	P_1
EU Tau	0.3227	35	5	P_1
SZ Tau	0.4982	43	6	P_1
EV Sct	0.4901	46	14	P_1
FF Aql	0.6503	34	7	P_0
V636 Cas	0.9231	46	5	P_0
V532 Cyg	0.5163	31	8	P_0
Y Oph	1.2335	71	10	P_0

Table 1 gives the Cepheid radii and their formal r.m.s. errors. For calculations of radii of spectroscopic binaries SU Cas, FF Aql and V532 Cyg, we used pulsational radial velocity curves (after taking into account orbital motion, with elements from Gorynya et al., 1996a).

In the period–radius diagram, all stars fall into two groups with different period–radius relations (Fig. 1):

Group 1: FF Aql, V636 Cas, V532 Cyg, and Y Oph

Group 2: FN Aql, V1162 Aql, BY Cas, SU Cas, V1726 Cyg, X Lac, EV Sct, EU Tau, and SZ Tau

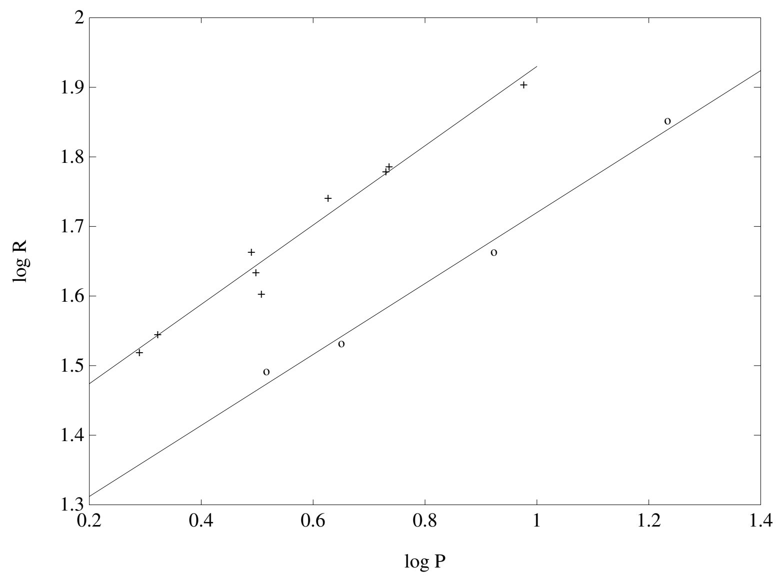

Figure 1. The period–radius diagram. Open circles, Group 1; crosses, Group 2

This segregation can be explained if we assume that stars of the two groups pulsate in different modes: group 1, in the fundamental tone; group 2, in the first overtone. Taking into account that $P_0 = P_1/0.71$, one can write:

$$\log R = \begin{matrix}1.21\\ \pm.03\end{matrix} + \begin{matrix}0.51\\ \pm.04\end{matrix} \log P_0 \qquad \text{for group 1}$$

$$\log R = \begin{matrix}1.36\\ \pm.02\end{matrix} + \begin{matrix}0.57\\ \pm.04\end{matrix} \log P_1 \qquad \text{for group 2}$$

or

$$\log R = \begin{matrix}1.27\\ \pm.03\end{matrix} + \begin{matrix}0.57\\ \pm.04\end{matrix} \log P_0 \qquad \text{for group 2}$$

With this assumption, the relations can be considered the same. This relation agrees well with that for single-mode Cepheids (Ripepi et al., 1997, Sachkov et al., 1997) and for double-mode Cepheids (Sachkov, 1997). Low-amplitude Cepheids have the same period–luminosity relation as the ordinary ones (Berdnikov et al., 1996). Therefore, the period–radius relations for low-amplitude and ordinary Cepheids must be the same.

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PHOTOMETRIC AND POLARIMETRIC OBSERVATIONS OF THE POST-AGB STAR SAO 124414

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Post-AGB stars are suspected to be in an intermediate evolutionary state between asymptotic giant branch and planetary nebula stages. Together with the study of long period variables (Mira Ceti type stars) we have performed a photometric and polarimetric monitoring of 4 post-AGB stars, from March to July 1997. In this paper, we present the preliminary results of these observations for one of these objects: SAO 124414.

The observations have been carried out with the photopolarimeter attached to the 50cm AZT-14 telescope of Byurakan observatory. Detailed description of the observational method and instruments has already been published (Eritsian, Nersisian, 1984 and Magnan et al., 1996). The observations have been done in B, V, R bands. The uncertainties in the photometric and polarimetric measurements are σ=0.01–0.02 mag and σ_P=0.1–0.2%, respectively. The uncertainty in the determination of the polarization angle is $\sigma(\theta)$=1–2°.

During the observational period, no significant light variation was detected. In Table 1 we present the results of photometric and polarimetric observations for the star SAO 124414. We display the Heliocentric Julian dates of observations (column 1), the B, V and R magnitudes (columns 2 to 4), the degree of polarization in B, V and R bands (columns 5 to 7) and the polarization angle (columns 8 to 10).

As one can see from the data listed in Table 1, while the brightness of the star is constant during the observational period, a significant time variation of polarization is detected. The absence of polarization of nearby background stars that we have also observed, the time variation and the wavelength dependence of linear polarization of SAO 124414 indicate that this detected polarization has an intrinsic character, as already mentioned in Trammell et al. (1994). This confirms that the star SAO 124414 has an extended circumstellar envelope (see for instance Hawkins et al, 1995). The varying polarized light that we have detected for SAO 124414 may be the result of inhomogeneities and/or unstable morphology of the nebula.

Table 1: Photometric and polarimetric measurements for SAO 124414

Julian date	B	V	R	P%(B)	P%(V)	P%(R)	θ(B)	θ(V)	θ(R)
2450603.33	9.58	8.61	8.42	3.0	2.0	1.8	124°	132°	127°
2450603.39	9.58	8.61	8.42	3.0	2.0	1.8	124	132	127
2450604.27	9.58	8.60	8.41	3.0	2.0	1.7	125	130	127
2450613.23	9.62	8.61	8.40	3.5	2.0	2.0	129	129	126
2450613.27	9.61	8.61	8.40	3.5	2.0	2.0	129	129	126
2450613.32	9.60	8.59	8.42	3.5	2.0	2.0	128	127	126
2450613.36	9.60	8.60	8.41	3.5	2.0	2.0	129	128	126
2450613.42	9.62	8.61	8.40	3.5	2.0	2.0	129	128	127
2450637.29	9.59	8.60	8.40	2.7	2.1	1.6	138	129	128
2450638.31	9.59	8.61	8.41	2.8	2.2	1.5	124	148	138
2450640.30	9.60	8.62	8.40	2.1	1.6	0.8	140	135	135
2450640.38	9.61	8.60	8.40	2.1	1.6	0.8	139	135	133
2450640.50	9.60	8.61	8.40	2.2	1.6	0.8	140	135	135
2450641.25	9.58	8.59	8.42	3.7	3.1	1.3	143	138	129
2450641.39	9.58	8.59	8.40	3.7	3.1	1.3	142	137	126
2450641.47	9.58	8.60	8.40	3.7	3.1	1.3	142	137	127

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PHOTOMETRIC AND POLARIMETRIC OBSERVATIONS OF MIRAS

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As a part of joint investigations on long period variables within the framework of the French–Armenian Jumelage in astronomy, the preliminary results of photometric and polarimetric observations of nine Miras are presented in this paper.

The observations have been carried out with the photopolarimeter attached to the AZT-14 50cm telescope of the Byurakan Observatory in the B, V, R bands. Nine long-period variables were observed from January to September 1997. The photopolarimeter works in the regime of amplification of the direct current and can serve as a photoelectric photometer when the polaroid is removed. A photomultiplier FEU 79 was used with a maximum of sensitivity in the spectral region 4000–4400 Å. A comparison star and a background star have been measured for with every programme star. The accuracy of the photoelectric observations in the BVR bands is about $0\overset{m}{.}02 - 0\overset{m}{.}05$. The uncertainties of the polarimetric measurements are of the order of 0.2%–0.3%. The position of the angle of polarization is determined with an accuracy of 2°–4°. A detailed description of the observational method and the instruments has already been published (Eritsian and Nersisian 1984).

Table 1 gives the B, V, R magnitudes in the Johnson system for six observed Mira stars. In three other cases (R Aql, RT Cyg and R Aqr) a polarization has been detected, as shown in Table 2, which gives in addition to the photometric magnitudes the degree of polarization in the B, V, R bands and the polarization angle. This polarization proved variable. Moreover the wavelength dependence and the absence of polarization of the nearby background stars demonstrate the intrinsic character of the light polarization.

The main result of the investigation is the detection of rapid variations on R Gem and R Boo, as shown in Figures 1 and 2. Similar rapid variations have already been detected on Y Ori (Melikian and Jakubov 1995) and on T Cep (Magnan et al. 1996).

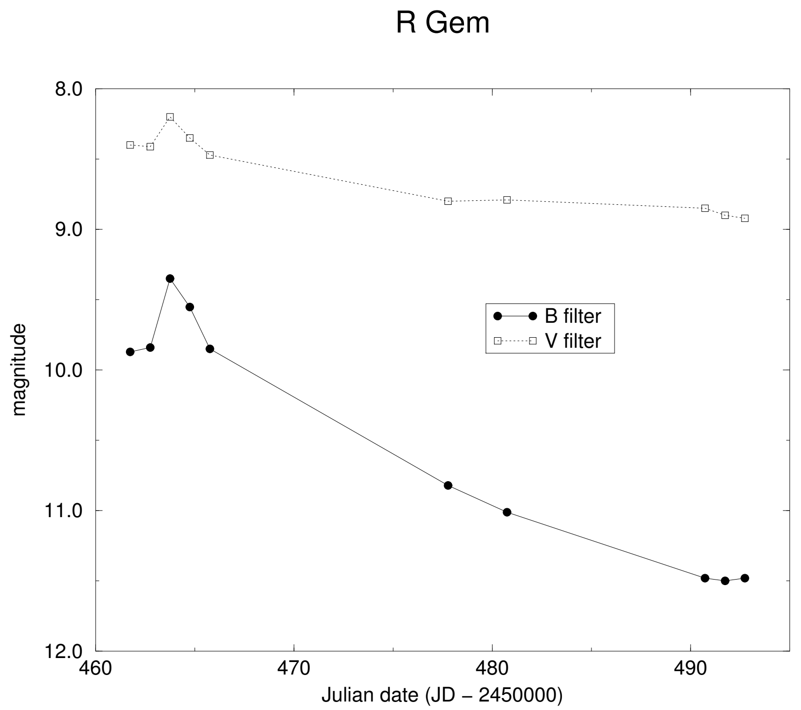

Figure 1. Rapid variation of R Gem

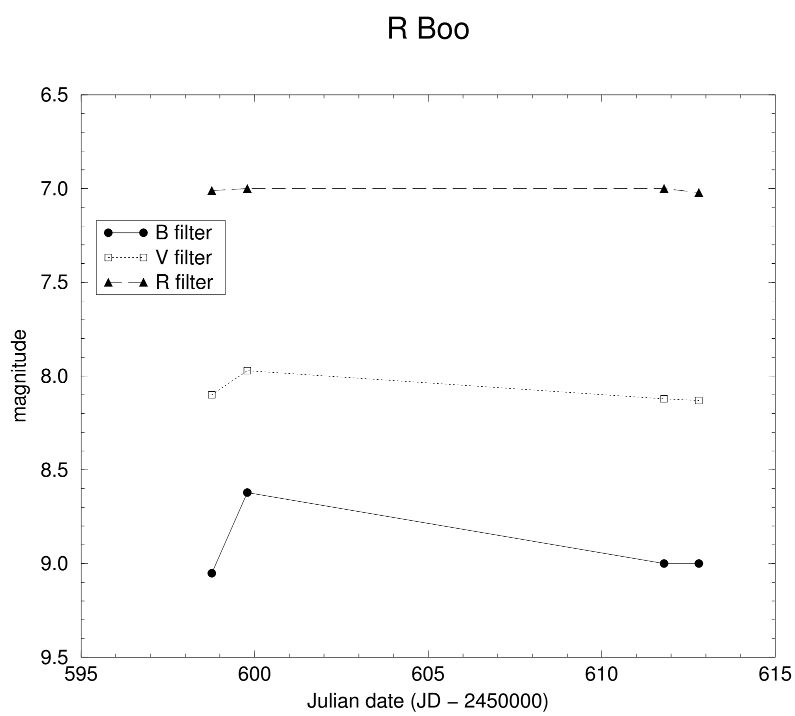

Figure 2. Rapid variation of R Boo

Table 1: Photometry of some Mira stars

Star	Julian Date (JD−2450000)	m_B	m_V	m_R
R Gem	461.243	9.87	8.40	-
	462.264	9.84	8.41	-
	463.250	9.35	8.20	-
	464.257	9.55	8.35	-
	465.271	9.85	8.47	-
	477.264	10.82	8.80	-
	480.250	11.01	8.79	-
	490.229	11.48	8.85	-
	491.229	11.50	8.90	-
	492.229	11.48	8.92	-
S Ori	462.333	9.28	9.03	-
	463.312	9.28	8.91	-
	464.312	9.22	8.78	-
	465.323	9.20	8.67	-
	477.312	9.07	8.65	-
	480.306	9.00	8.45	-
R Aur	476.236	9.18	7.33	-
	477.361	9.19	7.31	-
U Cam	490.285	10.74	8.64	-
	491.271	10.76	8.60	-
	492.278	10.74	8.62	-
R Boo	598.271	9.05	8.10	7.01
	599.285	8.62	7.97	7.00
	611.292	9.00	8.12	7.00
	612.299	9.00	8.13	7.02
X Oph	611.333	9.50	8.62	7.05
	612.337	9.47	8.57	7.05
	613.333	9.52	8.60	7.05

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Table 2: Photometry and polarimetry of 3 Mira stars

Star	Julian Date	m			P(%)			$\theta(°)$		
	(JD−2450000)	B	V	R	B	V	R	B	V	R
R Aql	602.292	10.90	9.70	7.40	-	0.8	1.0	-	38	40
	603.288	10.92	9.75	7.48	-	0.8	1.0	-	38	40
	604.271	10.92	9.71	7.40	0.7	0.8	1.0	35	40	40
	605.267	10.88	9.70	7.46	-	0.9	1.2	-	38	42
	687.271	8.60	7.90	6.30	1.5	1.8	1.5	44	42	40
	688.267	8.60	7.80	6.10	2.0	1.4	0.6	40	42	40
	690.292	8.55	7.80	6.27	1.6	1.4	-	48	40	-
	693.250	8.41	7.72	6.22	1.9	1.6	-	50	40	-
RT Cyg	658.243	7.72	7.08	-	-	-	-	-	-	-
	662.243	7.70	7.10	-	-	-	-	-	-	-
	685.243	9.27	7.74	-	1.1	1.1	1.8	40	45	45
	686.236	9.28	7.70	-	2.3	2.6	3.0	38	40	45
	687.243	9.36	7.72	-	1.1	1.2	1.2	40	42	50
	691.250	9.62	7.78	-	1.1	1.0	0.6	40	45	48
R Aqr	640.417	-	-	-	-	-	0.9	-	-	40
	671.250	9.86	8.60	-	4.1	3.0	1.8	45	38	40
	673.250	10.30	9.10	-	3.8	2.8	2.5	35	40	45
	690.292	10.81	10.13	-	5.7	3.0	2.5	42	37	45
	693.333	10.95	10.12	-	-	5.0	1.3	-	42	44

References:

Eritsian, M.H., Nersisian, S.E., 1984, Astrofizika, 20, 355
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Magnan, C., Mennessier, M.-O., Melikian, N.D., Eritsian, M.H., Karapetian, A.A., 1996, IBVS, No. 4390

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GSC 3639.01081: A NEW VARIABLE IN THE FIELD OF GK ANDROMEDAE

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While timing a minimum of the eclipsing binary GK Andromedae on JD 2450719 (to be published in BBSAG Bulletin No. 116), we got aware of the fact that one of the comparison stars, namely GSC 3639.01081 (α_{J2000} : $23^{\rm h}53^{\rm m}39^{\rm s}$; δ_{J2000} : $+45^\circ 37\overset{\prime}{.}35$), is a variable star. An electronic search indicates that this star has not been reported to be variable up to now.

The measurements were gathered with the 35cm SC-reflector of R. Szafraniec Observatory, Metzerlen, Switzerland. The telescope is equipped with a SBIG ST-6 CCD camera at its prime focus yielding unfiltered photometry at the 0.01 mag level. Due to the proximity of all comparison stars to the variable no extinction correction was applied to the data given below. Observing conditions during the night of JD 2450719 were photometric with neither moon nor clouds interfering.

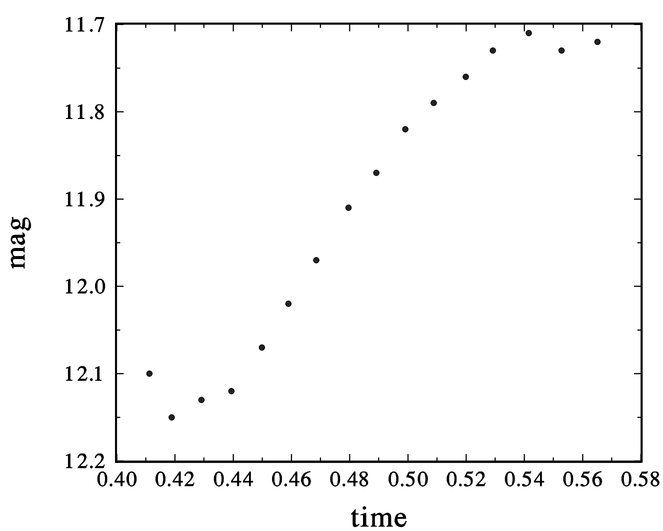

Figure 1. Unfiltered CCD light curve of GSC 3639.01081 (comparison star GSC 3639.01089). Heliocentric UTC on JD 2450719

In Figure 1, we present the light curve of GSC 3639.01081. The time is given in heliocentric UTC and the stars GSC 3639.01089 and GSC 3639.01754 were employed as comparison and check star, respectively. The difference in brightness between these two stars turned out to be constant throughout the observing run at 0.38 ($\pm$0.01) mag.

The light curve seems to indicate an eclipsing type variation for GSC 3639.01081. This preliminary finding is supported by an earlier observing run lasting for three hours (JD 2450462.22 to JD 2450462.34), during which the star was found to be at its maximum brightness and showing no variation exceeding the accuracy of the photometry.

This research made use of the SIMBAD database operated by the CDS, Strasbourg, France. The author wishes to thank the "Emilia Guggenheim-Schnurr Foundation" for financial support.

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THE ECLIPSING BINARY STAR NSV 03999 IN CAMELOPARDALIS

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NSV 03999 (= CSV 006617 = BV 0217 = GSC 4631.1941) was announced as an eclipsing binary system by Strohmeier (1958). In the NSV (Kholopov, 1982), a photographic brightness variation from $10^{m}_{\cdot}6$ to $11^{m}_{\cdot}1$ and spectral type F2 were given without supplying further information. In order to verify these data, the star was observed in the V band from Monegrillo Observatory (Spain), using the 0.4m telescope and a CCD light detector. NSV 03999 was monitored for 11 nights, from March 15 to April 11, 1997 obtaining more than 600 photometric measurements. GSC 4631.1830 (= PPM 001390 = SAO 001315) was used as comparison star and GSC 4631.1814 and GSC 4631.1794 were used as check stars.

Photometric observations showed that NSV 03999 is in fact an Algol type binary star with a period over 1 day. Phase curve (Figure 1) indicates that the amplitude of the light variation is 0.45 ± 0.02 magnitude at primary minimum and 0.28 ± 0.02 magnitude at secondary minimum. The following ephemeris was computed:

$$\begin{array}{rcl} \text{Min. I} = \text{HJD } 2450534.6410 & + & 1^{d}_{\cdot}09172 \times E \\ \pm\ 0.0002 & \pm & 0.00012 \end{array}$$

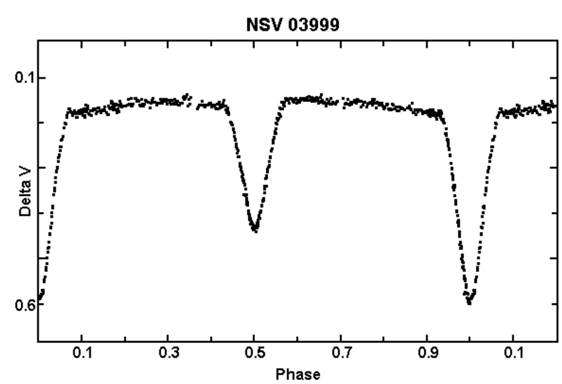

Figure 1.

A list of minimum timings for the above given ephemeris was also obtained after using the Kwee and van Woerden's (1956) method. These are given in Table 1. The typical error for the given minima is $0\overset{d}{.}0002$.

Table 1

HJD + 2400000	Epoch	Minimum
50534.6410	0.0	I
50537.3710	2.5	II
50543.3749	8.0	I
50550.4712	14.5	II

References:

Kholopov, P. N., editor, 1982, New Catalogue of Suspected Variable Stars, Moscow
Kwee, K. K., van Woerden, H., 1956, BAN, 12, 327
Strohmeier, W., 1958, KVB No. 23

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NEW M-TYPE VARIABLES IN DARK CLOUD REGIONS

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During the spectral survey of M type stars in three dark cloud regions, 22 new red variables have been discovered.

The observations have been carried out with the 40" Schmidt telescope of the Byurakan Astrophysical Observatory using the 4°objective prism. As RG1 and RG2 filters and Kodak 103aF, IIaF and IIIaF photoemulsions have been used, the spectral region 6000–7000 Å has been recorded. The dispersion of the spectra is about 1100 Å/mm near Hα. The limiting magnitude of the photographic plates in the red light is R=16.0, which gives the possibility to detect all M type stars brighter than R=15.0. The observations have been done over a period of 10 years: in 1979, 1985 and 1989.

The method of discovering M giants of late spectral classes is based on the availability of two absorption zones of TiO in the spectra of these stars near λ 6158 Å and λ 6651 Å. In this manner 96 new M type stars have been discovered in the total area of 48 deg^2 that was investigated (Melikian and Karapetian, 1997).

The comparison of the data for those 96 stars at different years allowed us to find 22 stars showing variability. The results for those 22 stars are presented in Table 1, which successively gives (1) the number of the star, (2) the number from the paper by Melikian and Karapetian (1997) (where the identification charts may be found), (3) the α coordinate (1950.0) in units of hours, minutes and seconds, (4) the δ coordinate (1950.0) in units of degrees, arcminutes and arcseconds (5-7) the B,V,R magnitudes measured by the method of King and Raff (1977), (8) the amplitude of the light variation in the red light and (9) the identification in the IRAS catalogue.

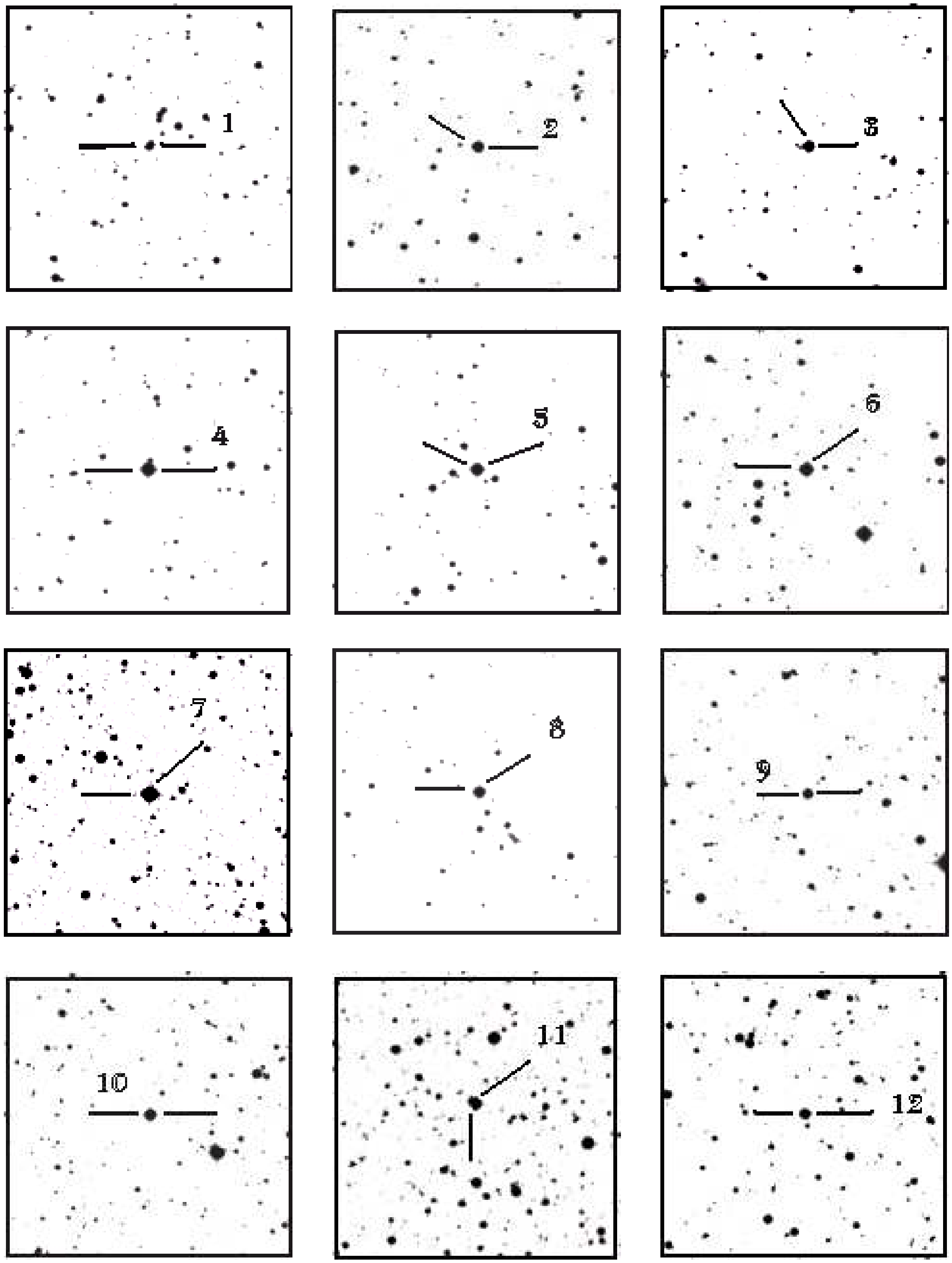

Figure 1. Identification charts of the new variables. The size of each chart is $4'\!.2 \times 4'\!.2$. North is up and east is to the left.

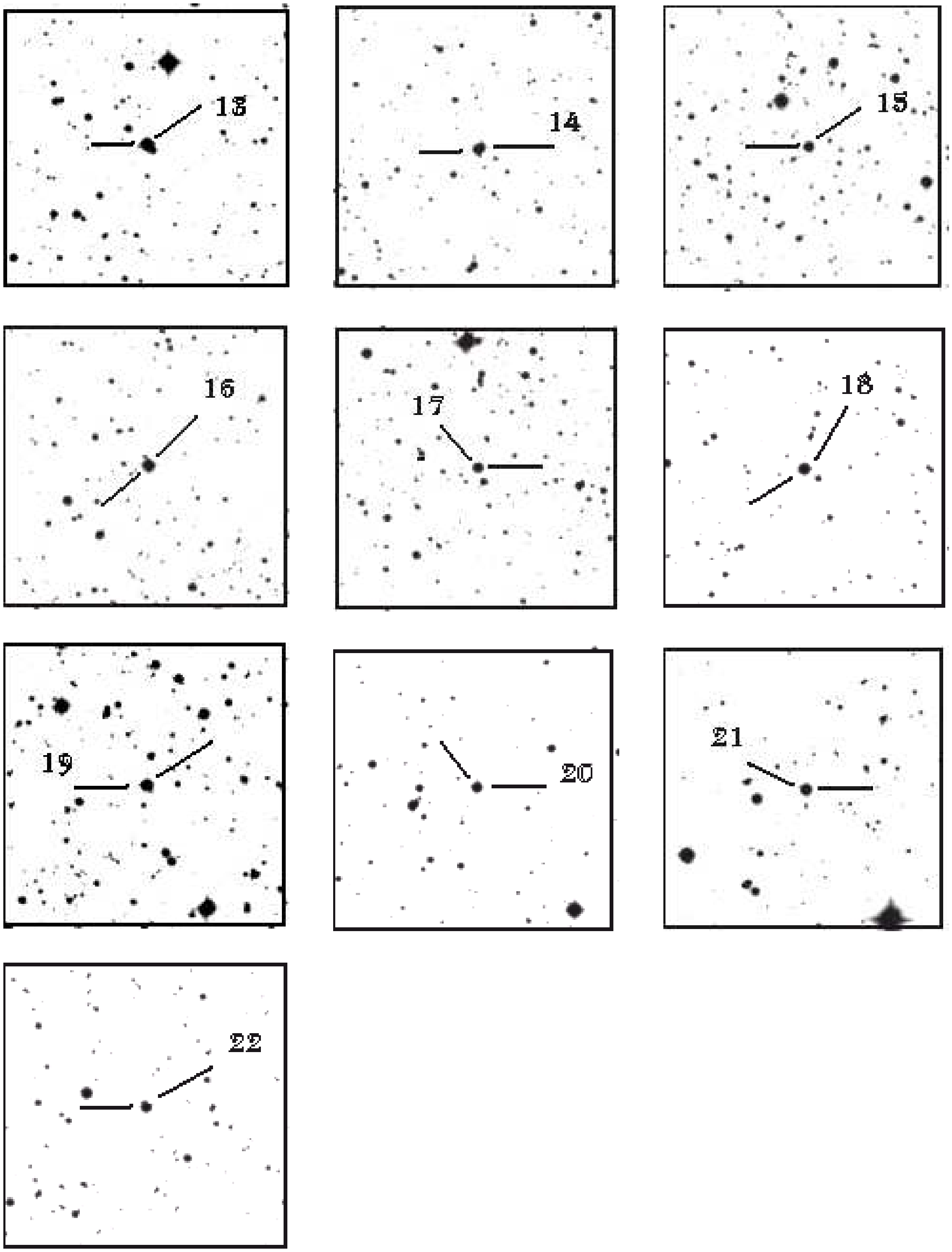

Figure 1. (cont.)

Table 1: New M variables in dark cloud regions

N	N*	α	δ	B	V	R	ΔR	IRAS identifier
1	2	20 46 00.3	53 16 30	16.4	14.0	12.8	2.0	
2	7	20 48 23.7	53 41 33	16.7	14.1	12.8	0.7	IRAS 20483+5358
3	10	20 51 05.1	53 15 02	15.9	13.8	12.8	0.8	IRAS 20510+5314
4	11	20 51 18.8	52 51 06	15.4	13.4	12.4	0.9	IRAS 20513+5251
5	16	20 54 45.1	55 39 05	14.1	12.4	11.6	0.7	
6	22	20 56 20.6	54 55 34	13.4	12.4	11.9	0.7	IRAS 20563+5455
7	26	20 57 19.4	53 30 24	15.4	13.4	12.4	0.5	
8	29	20 57 43.8	55 30 58	16.7	15.0	14.2	1.0	IRAS 20577+5530
9	32	21 01 23.6	54 32 03	16.2	13.7	12.4	0.6	IRAS 21014+5432
10	41	21 07 47.1	54 43 58	13.8	11.6	10.5	0.6	
11	54	21 22 42.0	54 44 56	16.2	13.5	12.2	0.8	
12	55	21 23 02.9	55 57 39	16.2	13.7	12.5	1.2	
13	63	21 32 33.9	55 21 52	13.0	11.2	10.3	0.6	
14	72	21 34 59.7	53 57 59	16.2	13.5	12.2	0.6	IRAS 21349+5357
15	73	21 35 04.4	56 47 27	16.2	13.7	12.5	0.8	
16	78	21 37 51.5	56 03 36	14.0	12.6	11.9	0.7	IRAS 21378+5603
17	81	21 38 14.3	54 31 05	09.6	08.7	08.3	0.8	
18	83	21 40 28.9	54 44 19	16.2	13.5	12.2	0.5	
19	85	21 44 45.2	54 53 52	15.9	13.4	12.2	0.6	
20	91	23 27 17.5	64 34 55	15.4	13.3	12.2	0.8	
21	95	23 50 30.1	64 03 46	14.0	12.4	11.6	0.7	
22	96	23 51 01.3	63 32 08	15.4	13.3	12.2	0.6	

References:

Melikian N.D., Karapetian A.A., 1997, Astrofizika, in press.
King V.R., Raff M.I., 1977, PASP 89, No. 528, 120.

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BY APODIS: A NEW MIRA VARIABLE†

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BY Aps ($\alpha = 16^{\rm h}26^{\rm m}58^{\rm s}$, $\delta = -75°18'28''$, epoch = 2000.0) was discovered as a variable star by Hoffmeister (1963) and designed as S5581. It is listed in the General Catalogue of Variable Stars (Kholopov et al. 1985) as an L-type variable, i.e., a star presenting slow irregular light changes. The quoted brightness variation is $m_{\rm pg} = 13.6 - (15.6)$.

We have observed this star in the course of a photometric and spectroscopic program on southern and equatorial irregular variables (Cieslinski et al. 1997a, 1997b). The photometric observations (Table 1) were obtained with the FOTEX and FOTRAP (Jablonski et al. 1994) photometers at the 0.6-m Zeiss and 1.6-m Boller & Chivens telescopes of the CNPq/Laboratório Nacional de Astrofísica, Brazil. The spectroscopic observations were carried out in 1986 with the Boller & Chivens Spectrograph + 2D–Frutti on the 1.0-m Yale telescope at the Cerro Tololo Interamerican Observatory, Chile. The spectral coverage is 3900–6800 Å, with 7 Å resolution. Several spectra of BY Aps were collected and in all occasions the object showed a continuum compatible with M3–M7II spectral types.

In order to search for periodicities we analysed the photometric data of BY Aps using a DFT algorithm (Deeming 1975). A modulation with a period of $240\overset{\rm d}{.}40$ is clearly evident in the V data (Fig. 1). The amplitude of this modulation is ~4 mag and appears to be fairly coherent along the time interval in which our data were collected (~12 years). The behaviour of the $U-B$, $V-R$ and $R-I$ indices is quite consistent with that of Mira-type objects (Celis 1977, de Laverny et al. 1997). The $B-V$ index shows enhanced scatter around phase ~ 0.25, similar to what is seen for R Cha in phase ~ 0.8 and for RU Oct in phase ~ 0.95 (de Laverny et al. 1997). R Car and R Hya may have a similar effect on the descending branch of the light curve (Celis 1977). This colour index is also relatively constant in the range of phases 0.5 – 1.0, but this is not rare (see for example R Cha, RY Hyi, RU Oct and U Tuc in de Laverny et al. 1997)

The ephemeris for the times of maximum light of BY Aps is as follows:

$$T_{\rm max}({\rm JD}) = 2447909.6(\pm 1.3) + 240.40(\pm 0.23) \times {\rm E}$$

The presence of a periodic large amplitude variation and the M spectral type suggest BY Aps to be a Mira-type variable. A finding chart from the Digitized Sky Survey (SkyView)[1] is shown in Fig. 2.

†Based on observations made at CNPq/LNA, Brazil and CTIO, Chile

[1] SkyView was developed under NASA ADP Grant NASS-32068 and under the auspices of the High Energy Astrophysics Science Archive Research Center (HEASARC) at the GSFC Laboratory for High Energy Astrophysics.

Table 1: Photoelectric photometry of BY Aps

HJD	V	U−B	B−V	V−R	R−I	σ_V	σ_{U-B}	σ_{B-V}	σ_{V-R}	σ_{R-I}
2446179.6400	14.75	–	1.26	–	–	0.07	–	0.11	–	–
2446230.5844	12.78	–	1.27	–	–	0.04	–	0.05	–	–
2446232.5495	12.70	0.46	1.30	–	–	0.04	0.06	0.05	–	–
2446283.5500	14.76	–	1.53	–	–	0.06	–	0.12	–	–
2446284.5956	14.76	–	1.67	–	–	0.05	–	0.10	–	–
2446285.4846	14.74	–	1.40	–	–	0.04	–	0.06	–	–
2446287.4414	14.80	–	1.53	–	–	0.04	–	0.06	–	–
2446291.5198	14.98	–	1.45	–	–	0.06	–	0.07	–	–
2446292.5447	14.94	–	1.32	–	–	0.04	–	0.06	–	–
2446353.4322	16.33	–	1.26	–	–	0.20	–	0.18	–	–
2446550.7195	15.30	0.51	1.39	–	–	0.03	0.16	0.04	–	–
2446589.6323	16.30	–0.05	1.19	–	–	0.06	0.10	0.06	–	–
2446591.5990	16.33	–	1.19	–	–	0.07	–	0.06	–	–
2446618.5180	15.91	0.29	1.28	–	–	0.08	0.10	0.08	–	–
2446677.4199	13.45	0.55	1.23	–	–	0.04	0.12	0.05	–	–
2446706.4271	12.37	0.81	1.37	–	–	0.03	0.07	0.04	–	–
2446716.4279	12.53	0.83	1.40	–	–	0.04	0.12	0.05	–	–
2446878.6568	15.03	0.27	1.33	–	–	0.08	0.20	0.10	–	–
2447240.7907	14.59	0.80	1.36	–	–	0.06	0.20	0.06	–	–
2447335.5286	15.73	–	–	2.43	2.21	0.10	–	–	0.10	0.08
2447351.5930	15.66	–	–	–	–	0.10	–	–	–	–
2447626.8129	14.29	–	1.29	2.12	1.99	0.05	–	0.07	0.04	0.03
2447642.8299	13.59	–	1.18	1.96	1.91	0.05	–	0.10	0.05	0.02
2447716.5571	14.44	–	1.47	2.33	2.07	0.05	–	0.13	0.05	0.03
2447718.5376	14.57	–	1.51	2.43	2.07	0.06	–	0.12	0.05	0.02
2447739.4668	15.33	–	1.58	2.48	2.21	0.07	–	0.14	0.06	0.03
2447740.4637	15.35	–	1.41	2.49	2.20	0.08	–	0.12	0.09	0.05
2447741.5508	15.54	–	1.33	2.67	2.17	0.09	–	0.15	0.07	0.03
2447742.4297	15.46	–	1.35	2.59	2.19	0.07	–	0.15	0.07	0.03
2447802.4273	16.35	–0.05	1.25	2.55	2.24	0.10	0.18	0.10	0.07	0.05
2448443.5614	14.40	–	1.76	2.28	2.00	0.04	–	0.10	0.03	0.02
2448444.5251	14.48	–	1.57	2.32	2.02	0.04	–	0.08	0.03	0.02
2449249.4309	16.19	–	–	2.72	2.27	0.15	–	–	0.10	0.08
2449897.4309	14.72	0.12	1.27	2.17	2.19	0.04	0.12	0.05	0.03	0.03
2450291.4298	13.27	–	1.28	1.53	1.98	0.05	–	0.15	0.06	0.03
2450317.4880	12.48	0.83	1.27	1.29	1.76	0.03	0.15	0.06	0.04	0.03
2450320.4658	12.47	–	1.40	1.31	1.75	0.06	–	0.13	0.06	0.03
2450349.4283	13.89	–	–	1.98	2.05	0.10	–	–	0.10	0.07
2450362.4669	14.22	–	1.32	1.96	2.09	0.06	–	0.15	0.05	0.04
2450630.6798	15.40	–	1.51	2.00	2.26	0.10	–	0.20	0.08	0.07
2450674.4840	16.27	–	–	–	2.37	0.20	–	–	–	0.13

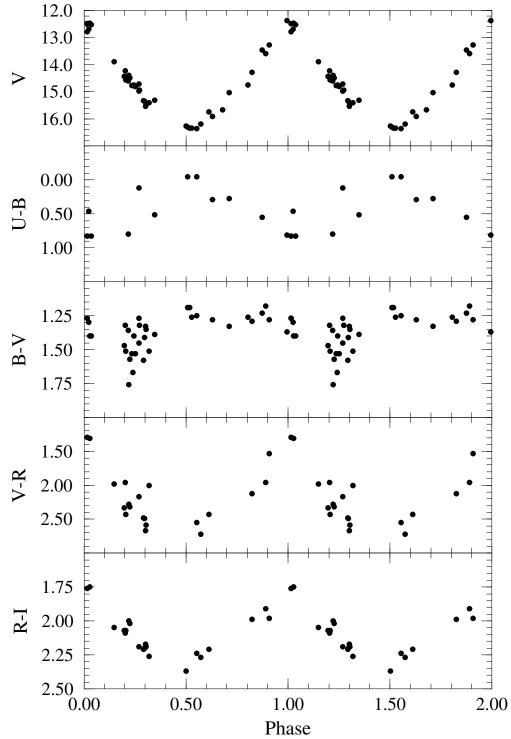

Figure 1. The photometric data of BY Aps folded on the 240^{d}.40 pulsational period.

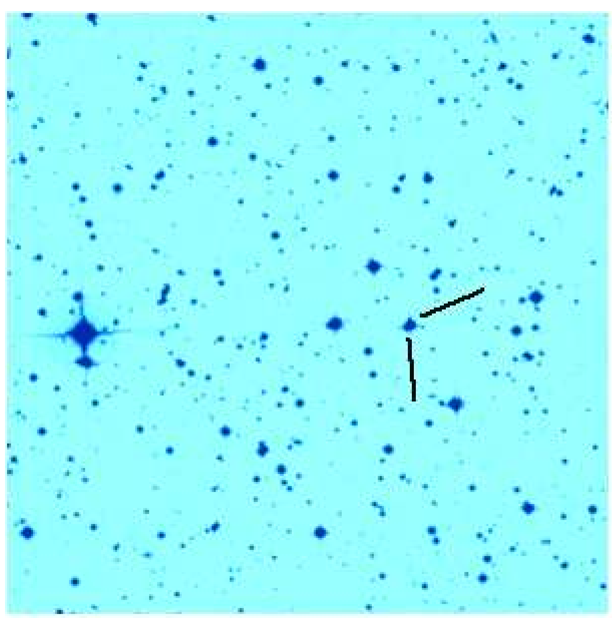

Figure 2. A 8'.5×8'.5 finding chart for BY Aps. North is up and East to the left.

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GG Vel: MORE TIMES OF MINIMA AND A PERIOD STUDY

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We present new photoelectric (hereafter pe) determinations of minima of the detached binary GG Vel = GSC 7690:2681 = HD 79459, V $\simeq 8^{\mathrm{m}}_{.}5$, Sp. T. = A0V. Other available minima are photographic (Strohmeier and Patterson 1967); these elements were also listed by Strohmeier and Knigge (1969). The first pe elements were given by Cerruti (1981). With these minima, covering approximately 4000 cycles, a study of the period showed that it is double that found previously. As shown in IBVS 2052 and later confirmed by the light curves, the system is composed of stars of nearly the same temperature which produces the approximately equal depths of primary and secondary minima.

The observations reported here were made in 1983 and 1997. The first were performed at Cerro Tololo Interamerican Observatory[1] in Chile with the Lowell telescope, refrigerated phototube EMI 2070, UBV standard filters and associated single-channel photon counting techniques. The 1997 data were obtained at the Sutherland site of the South African Astronomical Observatory (SAAO) using the 0.5m telescope and single-channel photometer. The latter employs a cooled Hamamatsu R943-02 GaAs photomultiplier and standard UBV$(RI)_C$ filters. The comparison star was GSC 7690:0284 = HD 79415(A0V) that is ten arcminutes from the variable and the check star was GSC 7690:0911 = HD 80055(A0V).

The resulting times of minimum light were determined by the polynomial line method (Guarnieri et al. 1975, Ghedini 1982) and are the last entries in Table 1 (JD 244 5435, 245 0501 and 0504). Also included in this table are the photographically determined times of minima and the earlier pe minima, calculated with the new period. The dispersion for each minimum is in brackets following the minimum itself; for the photographic minima, this was estimated from a linear solution with equal weights, taking the residuals of the respective points. The Table also contains the associated cycle number, E, and in the final column the corresponding residual, O−C.

We made a least squares weighted linear solution taking into account all available minima to derive an improved ephemeris and a possible period variation.

The linear solution is:

$$\begin{aligned} \text{Min I} = \text{HJD } 2443973.5778 \quad &+ \quad 2^{\mathrm{d}}_{.}9504549 \times E \qquad (1)\\ \pm\ 0^{\mathrm{d}}_{.}0019 \quad &\pm \quad 0^{\mathrm{d}}_{.}0000019 \text{ m.e.} \end{aligned}$$

[1]Operated by AURA Inc. under cooperative agreement with the NSF.

Table 1: Times of minima and residuals for GG Vel

Ref.	Min.	Band	HJD (sigma) 2400000+	E	O−C
1	I	pg.	38379.5420(0.0100)	−1896.0	0.0268
1	I	pg.	38382.5450(0.0400)	−1895.0	0.0793
1	I	pg.	38385.5430(0.0900)	−1894.0	0.1269
1	I	pg.	38441.3990(0.1100)	−1875.0	−0.0758
1	II	pg.	38490.2720(0.0800)	−1858.5	0.1147
1	II	pg.	38841.2920(0.0100)	−1739.5	0.0306
1	II	pg.	38844.2930(0.0400)	−1738.5	0.0811
1	I	pg.	38869.2330(0.1000)	−1730.0	−0.0577
1	I	pg.	38872.2270(0.0500)	−1729.0	−0.0142
1	II	pg.	39118.5430(0.1000)	−1645.5	−0.0612
1	II	pg.	39198.3130(0.0100)	−1618.5	0.0466
1	II	pg.	39201.3110(0.0600)	−1617.5	0.0941
1	I	pg.	39232.2370(0.0100)	−1607.0	0.0403
1	I	pg.	39235.2300(0.0500)	−1606.0	0.0829
1	II	pg.	39862.1010(0.0600)	−1393.5	−0.0178
1	I	pg.	39907.9640(0.0800)	−1378.0	0.1131
2	I	U	43899.8161(0.0012)	−25.0	−0.0003
2	I	B	43899.8180(0.0006)	−25.0	0.0016
2	I	V	43899.8150(0.0013)	−25.0	−0.0014
2	I	U	43902.7623(0.0008)	−24.0	−0.0046
2	I	B	43902.7610(0.0013)	−24.0	−0.0059
2	I	V	43902.7628(0.0006)	−24.0	−0.0041
2	I	U	43908.6744(0.0011)	−22.0	0.0066
2	I	B	43908.6721(0.0017)	−22.0	0.0043
2	I	V	43908.6737(0.0010)	−22.0	0.0059
2	I	U	43973.5725(0.0007)	0.0	−0.0053
2	I	B	43973.5706(0.0011)	0.0	−0.0072
2	I	V	43973.5714(0.0012)	0.0	−0.0064
2	I	U	44306.9778(0.0009)	113.0	−0.0014
2	I	B	44306.9798(0.0007)	113.0	0.0006
2	I	V	44306.9765(0.0008)	113.0	−0.0027
3	II	U	45435.5147(0.0022)	495.5	−0.0135
3	II	B	45435.5145(0.0012)	495.5	−0.0137
3	II	V	45435.5151(0.0030)	495.5	−0.0131
4	II	B	50501.4748(0.0018)	2212.5	0.0154
4	II	V	50501.4730(0.0020)	2212.5	0.0136
4	II	R	50501.4739(0.0023)	2212.5	0.0145
4	II	I	50501.4753(0.0032)	2212.5	0.0159
4	II	B	50504.4085(0.0017)	2213.5	−0.0013
4	II	V	50504.4071(0.0015)	2213.5	−0.0027
4	II	R	50504.4086(0.0010)	2213.5	−0.0012
4	II	I	50504.4104(0.0020)	2213.5	0.0030

References: 1) Strohmeier and Patterson;
2) Cerruti; 3) 1983 minimum; 4) 1997 minima.

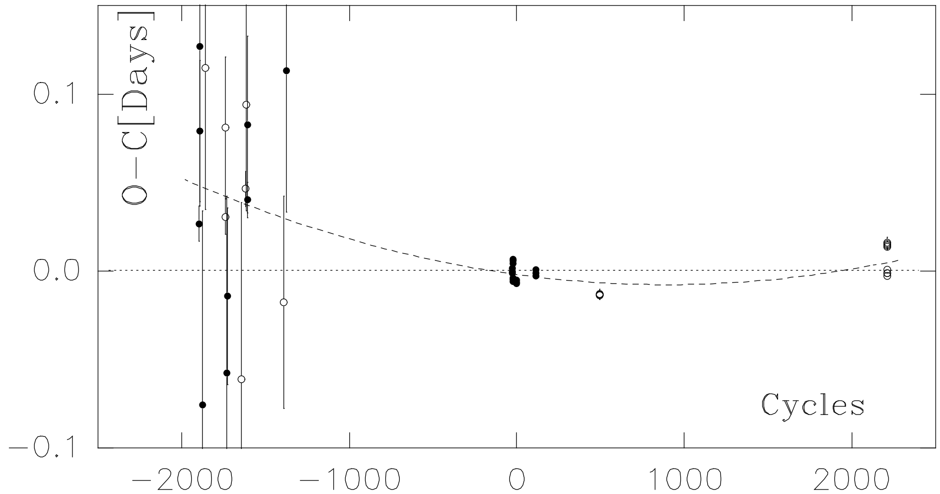

Figure 1. Behavior of the O−C residuals for GG Vel from Formula (1). Hollow circles stand for primary minima.

We conclude that the period has not changed significantly over the 4000 revolutions (cycles) covered by the available observations. The behaviour of the O−C residuals is depicted in Figure 1.

The author would like to thank the staff and Director of CTIO for their hospitality and Mr. Francois van Wyk for observations made at the SAAO.

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V829 AQUILAE IS A PULSATING STAR WITH A VARIABLE LIGHT CURVE

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The star V829 Aquilae = BD +03°4145 = AN 122.1935 = GSC 484.00065 (α_{J2000} : $19^{\rm h}46^{\rm m}57^{\rm s}$; δ_{J2000} : $+03°30'28''$; spectral type: F5) was found to be variable by Hoffmeister (1935) from photographic photometry at Sonneberg Observatory, Germany. He remarked that the star was "difficult" and "possibly an eclipsing binary". Based on this scant information, the author started a visual survey (Diethelm, 1977) that led to the determination of provisional elements. These elements were adopted in the GCVS (Khopolov et al., 1985).

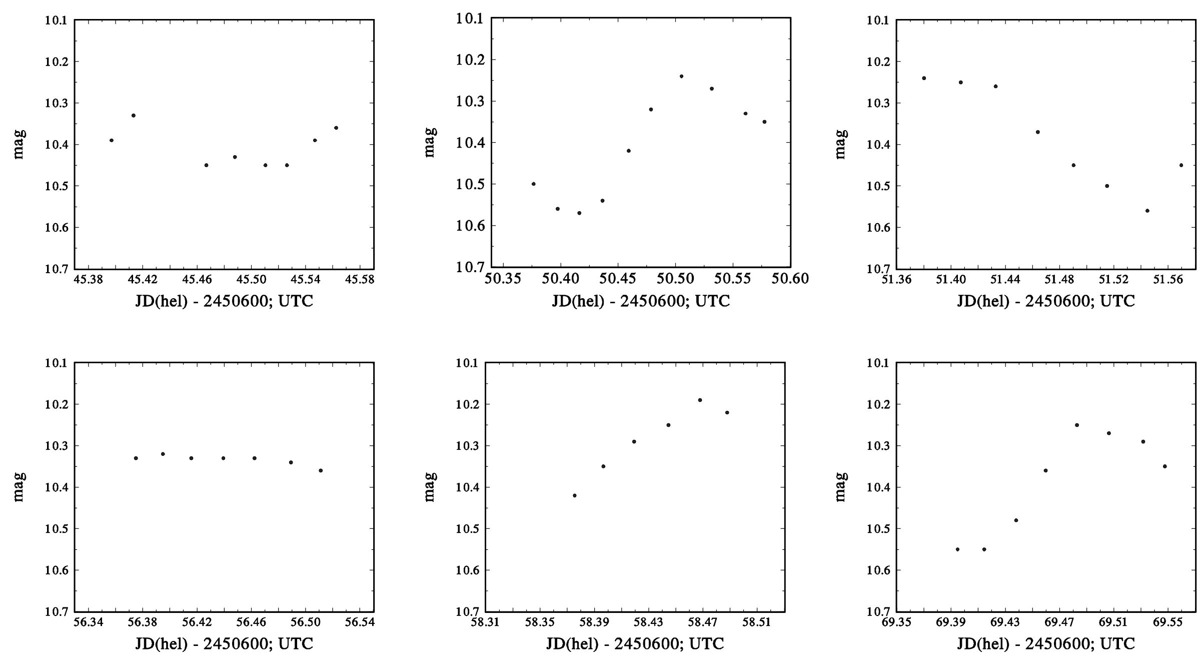

Figure 1. Unfiltered CCD light curve of V829 Aquilae during six nights in 1997

In order to investigate the validity of the preliminary elements, we reobserved V829 Aquilae with the 35cm SC-reflector of R. Szafraniec Observatory, Metzerlen, Switzerland, equipped with an SBIG ST-6 CCD camera at its prime focus. The unfiltered CCD photometry is accurate at the 0.1 magnitude level for objects as bright as V829 Aquilae (11th magnitude). Since both the comparison star (GSC 484.00267) as well as the check star (GSC 484.00227) lie within a few arcminutes of the variable, no extinction correction was necessary. A total of 61 observations in 1995 and 88 observations in 1997 were secured. In Figure 1, we present the data from six nights in 1997 (JD 2450645, 2450650, 2450651, 2450656, 2450658 and 2450669) as an example for the photometric behaviour of V829 Aquilae. The comparison star proved to be constant during all the 25 nights when observations were gathered.

From these examples it is apparent, that the variation of V829 Aquilae shows a complex nature of a pulsating type. While in some nights, we observe a well established asymmetric pulsation light curve with a period of close to 0.3 days and an amplitude of about 0.4 magnitudes, in other nights the star shows little variation at an intermediate brightness level, which is reminiscent of the behaviour of VZ Cancri (Arellano Ferro et al., 1994; Cox et al., 1984) or AC Andromedae (Fitch and Szeidl, 1976).

Based on this comparison we conclude that V829 Aquilae is probably a multimode radial pulsator very much deserving further attention. We have tried to find the primary period of pulsation from our data. The 1997 observations can be fitted reasonably well with a principal period of $0\overset{d}{.}292$, but the data from 1995 cannot be presented with this period value. Our data are not numerous enough to establish the period values with any certainty. Any researcher wishing to use our data for a comprehensive period study is kindly invited to contact the author at the e-mail address given above.

This research made use of the SIMBAD database operated by the CDS, Strasbourg, France. The author wishes to thank the "Emilia Guggenheim-Schnurr Foundation" for financial support.

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NEW ELEMENTS FOR BW CASSIOPEIAE

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Beljawsky (1933) reported the variability of the star BW Cassiopeiae = SVS 281 = AN 372.1931 = GSC 4035.00408 (α_{J2000} : $01^{\rm h}39^{\rm m}29^{\rm s}$; δ_{J2000} : $+63°26'10''$) and gave the uncertain elements:

$$\mathrm{JD}(min, hel) = 2425999.26 + 1\overset{\mathrm{d}}{.}895 \ \times \ E \tag{1}$$

cited in the GCVS (Kholopov et al., 1985). No other source of information on the variability of BW Cas is known to the author.

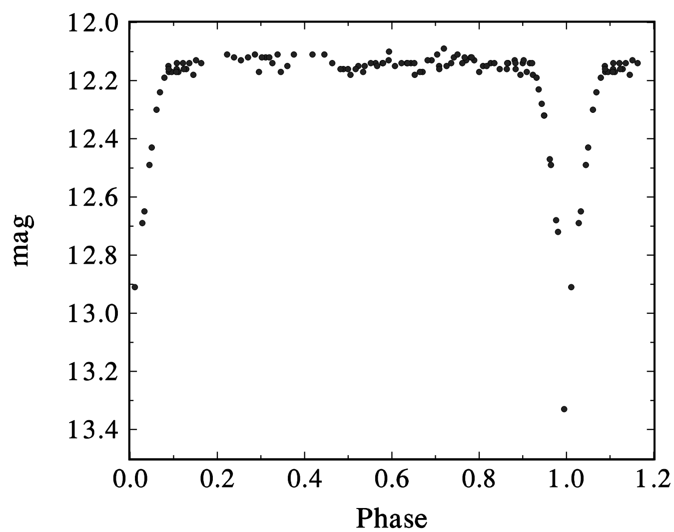

Figure 1. Unfiltered CCD light curve of BW Cassiopeiae folded with the elements (2)

We started to observe this neglected eclipsing binary this observational season with the 35cm SC-reflector of R. Szafraniec Observatory, Metzerlen, Switzerland, equipped with a SBIG ST-6 CCD camera at its prime focus. The unfiltered CCD photometry soon showed that the GCVS elements are spurious. The 109 observations on 17 nights from JD 2450692 to JD 2450727 (comparison star: GSC 4035.00401; check star: GSC 4035.00212), folded with the newly deduced elements of variation

$$\mathrm{JD}(min, hel) = 2450710.2973(2) + 1\overset{\mathrm{d}}{.}263 \times E \tag{2}$$

are shown in Figure 1.

The primary minimum is about 1.3 magnitudes deep (unfiltered CCD) and probably shows no sign of totality. The eclipse lasts for $0\overset{\mathrm{p}}{.}14$ ($0\overset{\mathrm{d}}{.}18$). A very shallow secondary minimum at phase $0\overset{\mathrm{p}}{.}5$ with an amplitude of about $0\overset{\mathrm{m}}{.}02$ can be discerned in our light curve. We will continue to observe minima of BW Cas in order to refine the elements (2) given above. Results of this work will be published in the BBSAG Bulletins.

This research has made use of the SIMBAD database operated by the CDS, Strasbourg, France. The author wishes to thank the "Emilia Guggenheim-Schnurr Foundation" for financial support.

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CONFIRMATION OF THE SU UMa NATURE OF V1504 Cyg

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Variability of V1504 Cyg was discovered by Beljawski (1936), and designated as S4693. Then, Crocker (1978) measured the outburst duration of 3–14 days and Kurochkin (1981) suggested that the variable star belongs to Z Cam-type dwarf novae with the outburst recurrence cycle of 5.823 days. Richter (1987) suspected that V1504 Cyg is an SU UMa-type dwarf nova with a recurrence time irregularly varying between 6.5 and 15 days. Raykov and Yushchenko (1988) suggested that V1504 Cyg is an SU UMa star having the recurrence cycle of the normal outburst of 9–10 days, at shortest 6 days, and that of the long outburst (lasting $\sim$ 10 days) of about 100 days. All these studies are based on photographic surveys. A spectrum obtained by Munari et al. (1997) shows the typical characteristics of dwarf novae in outburst.

We made photometric observations in 1994 October 31.402–31.531(UT) and in November 3.441–3.523(UT) during a long outburst, using a CCD camera (Thomson TH 7882, 576×384 pixels) attached to the Cassegrain focus of the 60 cm reflector (focal length = 4.8 m) at Ouda Station, Kyoto University (for details of the instrumentation, see Ohtani et al. 1992).

To reduce the readout noise and dead time, an on-chip summation of 2×2 pixels to one pixel was adopted. We used an interference filter which had been designed to reproduce the Johnson V band. The exposure time was 90 s. The dead time between exposures was typically 13 s.

After standard corrections of de-biasing and flat-fielding, the frames were processed by an aperture photometry package developed by Taichi Kato, Kyoto University. The magnitudes of the variable were determined using a local standard star marked as Comp in Figure 1. The comparison of the standard star with three check stars C_1, C_2, and C_3 in Figure 1 has indicated the constancy of the standard within 0.02 mag during our observations. It also gives 0.02 mag as the nominal 1-sigma error for a single frame in the differential magnitudes for the variable. The V magnitudes of the comparison star and the check stars (C_1–C_3) are given as 12.28, 13.71, 11.87, and 12.15 in the VSNET chart (available at the URL: ftp://ftp.kusastro.kyoto-u.ac.jp/pub/vsnet/charts/V1504_Cyg.ps) respectively.

The light curves are shown in Figure 2. Superhumps with an amplitude of about $0\overset{m}{.}2$ are clearly seen on 1994 Oct. 31, though the shape is distorted probably due to the secondary superhump on Nov. 3. We, thus, identify V1504 Cyg as being an SU UMa-type dwarf nova.

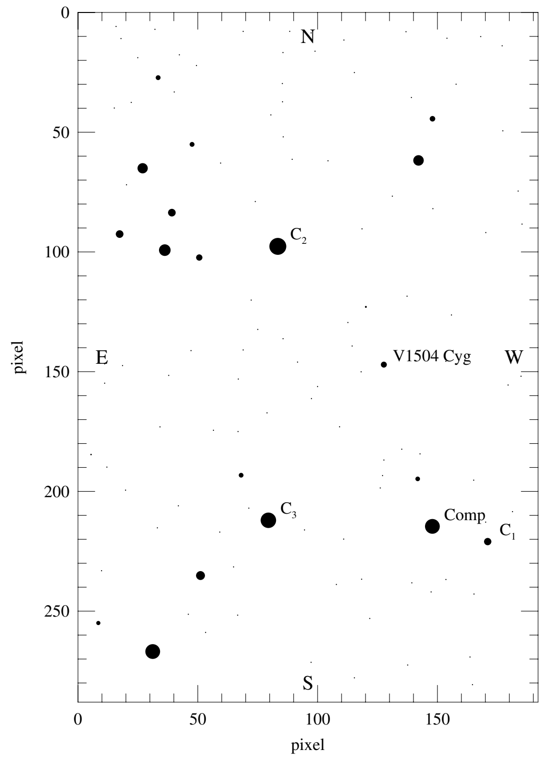

Figure 1. Finding chart of V1504 Cyg. The star marked as Comp is a local standard star whose V magnitude is 12.28 in the VSNET chart. C_1, C_2, and C_3 are check stars.

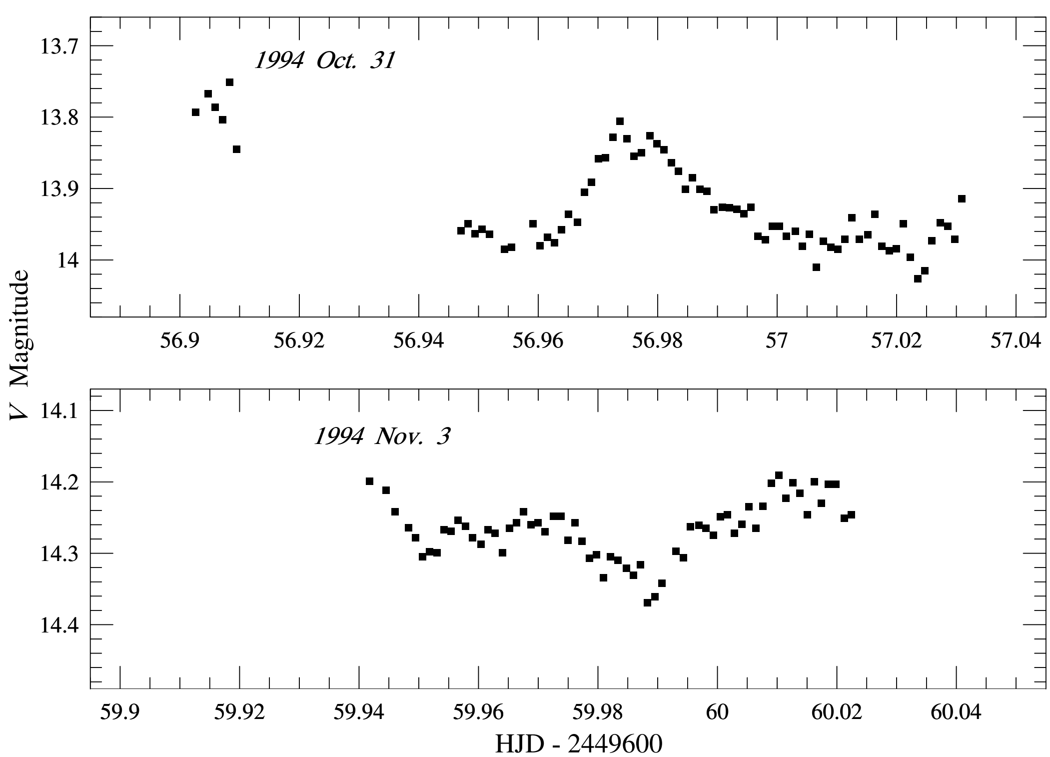

Figure 2. Superhumps observed on 1994 Oct. 31 and November 3.

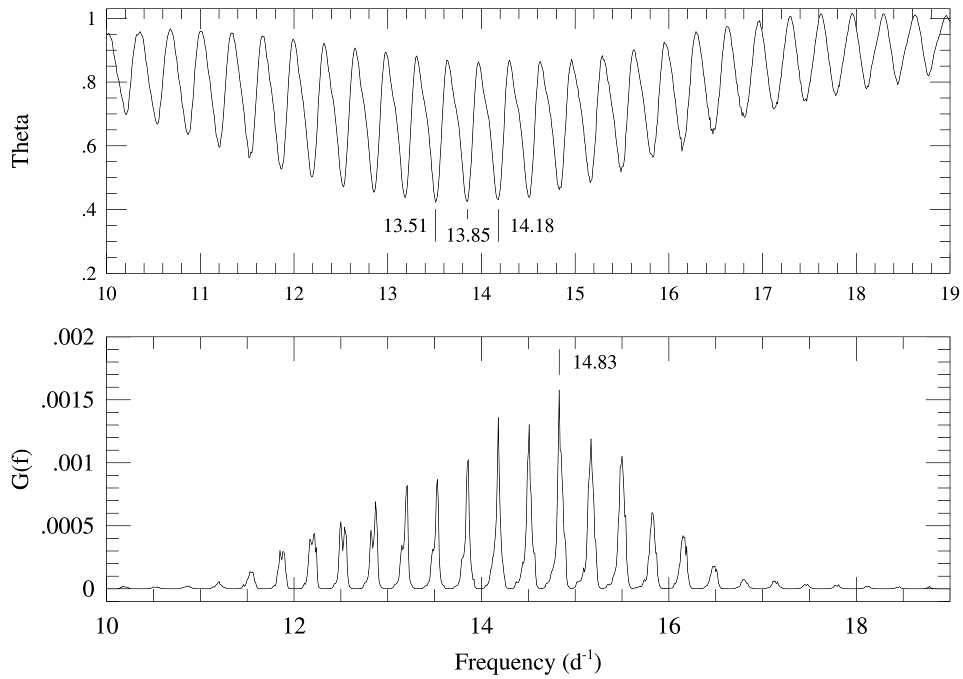

Figure 3. Results of period analyses using PDM technique (upper panel) and LANCELOT (lower panel) on the data shown in Figure 2. The inconsistency of the results may be caused by short coverages and change of the superhump shape.

The mean decline rate during the observations is ~0.11 mag d^{-1}. After subtracting the linear decline trend from all our data, we performed period analyses using the Phase Dispersion Minimization (PDM) method (Stellingwerf 1978) and LANCELOT (period analysis using artificial neural networks, Gaspani 1997, available at the URL: ftp://ftp.kusastro.kyoto-u.ac.jp/pub/vsnet/others/LANC/). The resultant theta diagram (PDM) and G(f) function (LANCELOT) are shown in Figure 3. The minimum and maximum points respectively correspond to the best estimates of the period. The results are inconclusive probably due to short coverages spanning 3 days and change of the superhump shape. The superhump period of V1504 Cyg is implied to be around $0^{\mathrm{d}}.07$, but this value has to be improved.

Based on the VSNET posts, Kato (1997) reported that the shortest interval between superoutbursts and normal outbursts are 116 d and 11 d, respectively, which are consistent with the values cited earlier in this paper (see Table 1). Those recurrence cycles are very short for the SU UMa star (see Table 1 in Nogami et al. 1997). In order to study the evolution of dwarf novae it is quite important to measure the orbital period precisely and reveal the recurrence pattern of outbursts in V1504 Cyg.

The authors are grateful to Adriano Gaspani (GEOS) for introducing us LANCELOT program. We thank T. Kato for his valuable comments. Part of this work is supported by a Research Fellowship of the Japan Society for the Promotion of Science for Young Scientists (DN).

Table 1: Recent behavior of V1504 Cyg. This table is according to Kato (1997).

Date (JD)	mag	outburst type	Note
2449514	13.4	super	
2449611	14.9	?	single obs.
2449630	14.3	?	single obs.
2449653	14.0	?	single obs.
2449660–662	14.4	?	
2449864	14.5	?	single obs.
2449895	15.6	?	single obs.
2449904–908	13.9	super	
2449930	15.9	?	single obs.
2449954	14.7	normal	
2449975	14.5	normal	
2450007	14.6	normal	
2450020–027	13.9	super	
2450110	14.3	?	single obs.
2450219	14.6	?	single obs.
2450229	14.9	?	related to 50219?
2450248	14.7	normal	
2450270	15.2	normal	single obs.
2450289	14.6	normal	
2450312	15.3	normal	
2450316	14.6?	?	single obs.
2450339–341	14.8	normal	
2450361	14.8	normal	
2450372	15.2	normal	
2450400–406	14.2	super	
2450419	14.9:	normal?	single obs.

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TIMES OF MINIMUM FOR AR Aur AND β Aur AND A NEW PERIOD DETERMINATION FOR β AURIGAE

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AR Aurigae: A photometrically determined time of primary minimum has been observed for the eclipsing binary AR Aur, which is a triple system showing light time effect. Nordström and Johansen (1993) pointed out that new times of minimum were needed to constrain the properties of the third component, which might be a pre-main-sequence star (Johansen and Nordström 1994). The new time of minimum occurred on

$$\text{HJD } 2449280.4987 \pm 0.0004$$

This value has been published in Danish by Johansen et al. (1994).

β *Aurigae*: For this bright eclipsing binary there has been some doubt whether the period is constant, and a changing period could indicate the existence of a third star. Also, the latest published ephemeris does not fit the later observations. Therefore new photoelectric observations were obtained, and two moments of primary minimum determined:

$$\text{HJD } 2449748.3530 \pm 0.0023$$
$$\text{HJD } 2450441.3552 \pm 0.0035$$

The new times of minimum, together with the previously published observations (see references in Table 1), have allowed us to determine a new ephemeris for β Aur:

$$MinI \;\; \text{HJD} = 2431076.7269 \pm 0.0010 + (3.96004732 \pm 0.00000032) \times E \qquad (1)$$

The period in Eq. 1 is at least to be considered a mean period, and it is concluded, that it has been impossible to verify any variation of the period of β Aur.

The new observations were carried out by H.S., using a 20 cm Schmidt-Cassegrain telescope equipped with an SSP-3 photodiode photometer and a Johnson V filter. Complete light curves are not necessary to discuss period variability. For AR Aur the phase interval covered is $\Delta\phi = 0.029$. For β Aur observations during 3 primary minima plus a few observations between the minima were obtained. Two primary minima with an epoch difference equal to 2 were combined using the period P_1, see below. The combined minimum, Sørn1, covers the phase interval $\Delta\phi = 0.041$ and the last minimum, Sørn2, covers 0.026. Finally the times of minimum were determined by means of the method given by Kwee and van Woerden (1956).

Table 1: Times of minimum for β Aur.

Series	Time of MinI	ΔT	$(O-C)_1$	E	com.	Reference
Tikhf	2415996.8650 ± .0047	15795-16201	−.0017	−3808	spH	Baker (1910)
Vogel	16499.7991 ± .0047	16471-16520	.0064	−3681	spH	Vogel (1904)
Belo1	16602.7683 ± .0080	16573-16610	.0144	−3655	spH	Belopolsky (1909)
Belo2	16602.7556 ± .0054	16573-16610	.0017	−3655	spH	ibid.
Belo3	17913.5293 ± .0020	17215-18638	−.0003	−3324	sp	ibid.
Baker	18269.9281 ± .0044	18181-18345	−.0058	−3234	spH	Baker (1910)
Stebb	19018.3848 ± .0046	18935-19119	.0020	−3045	pe	Stebbins (1911)
Berg1	20325.1972 ± .0029	19846-20961	−.0012	−2715	sp	Berg (1927-1929)
Berg2	22055.7475 ± .0060	21987-22772	.0084	−2278	sp	ibid.
Berg3	24202.0861 ± .0348	24171-24227	.0013	−1736	sp	ibid.
Smith	31076.7305 ± .0024	31047-31075	.0036	0	spH	Smith (1948)
Johs1	36842.5537 ± .0013	36836-36950	−.0021	1456	pe	Johansen (1971)
Johs2	37650.4025 ± .0022	37648-37694	−.0030	1660	pe	ibid.
Johs3	39099.7850 ± .0011	39068-39930	.0022	2026	pe	ibid.
GaGue	39234.4678 ± .0135	39130-39544	.0434	2060	spH	Galeotti, Guerrero (1968)
Humml	47439.64 ± .01	47439-48945	−.0024	4132	int	Hummel et al. (1995)
Hippc	48334.6119 ± .0012	47835-49043	−.0012	4358	pe	ESA (1997)
Sørn1	49748.3530 ± .0023	49748-49756	.0030	4715	pe	This paper
Sørn2	50441.3552 ± .0035	50441	−.0031	4890	pe	ibid.

Comments:

Col. 6: sp: spectroscopic, pe: photoelectric, int: interferometric observations. H: It is not mentioned whether the times have been corrected to the Sun or not. If *not*, the following corrections should be added to the values of Col. 2 : Tikhf: +.0028, Vogel: +.0045, Belo1: −.0029, Belo2: −.0030, Baker: +.0035, Smith: +.0052, GaGue: +.0024. This would change the period to 3.96004709 ± 0.00000043, where the increased scatter indicates that in most cases the times have already been reduced to the Sun.

Tikhf: Concerning HJD correction see Belo1,2,3 and Baker.

Belo1,2,3: Belo1 (ultraviolet) and Belo2 (blue) are observed on the same nights. We consider Belo2 to be most reliable since systematic errors could exist in the ultraviolet. Belopolsky gives heliocentric PMT (Pulkovo Mean Time) for the times of Belo3. In his discussion he does not use Belo1 and Belo2 and he mentions their times only as PMT. He uses the Tikhf series (observed by Belopolsky himself); however he mentions its times as PMT, the same values of times are referred to and used by Vogel and Baker.

Baker: Baker computed new spectroscopic elements for all data between 1900 and 1910. For the Tikhf and Vogel series he introduces a systematic error in the fourth decimal in the transformation of times from PMT and CET to GMT, and his own observations are reduced to normal points in phases published only with 3 decimals of a day. He does not mention heliocentric correction. Thus maybe some astronomers of that time using the long exposure times with the nonlinear photographic technique did not care to apply the

HJD correction or maybe the time designation made by Belopolsky is incomplete.

Berg1,2,3: The observations are carried out by Belopolsky. The large σ of Berg3 is due to the fact that 5 out of the 6 observations are at phases near maximum velocity.

Johs1,2,3: Systematic differences exist between the series (Johs1,2) and Johs3, since the photometric elements determined from the light curves differ systematically. Thus the errors of Col. 2, which are internal errors, are too small.

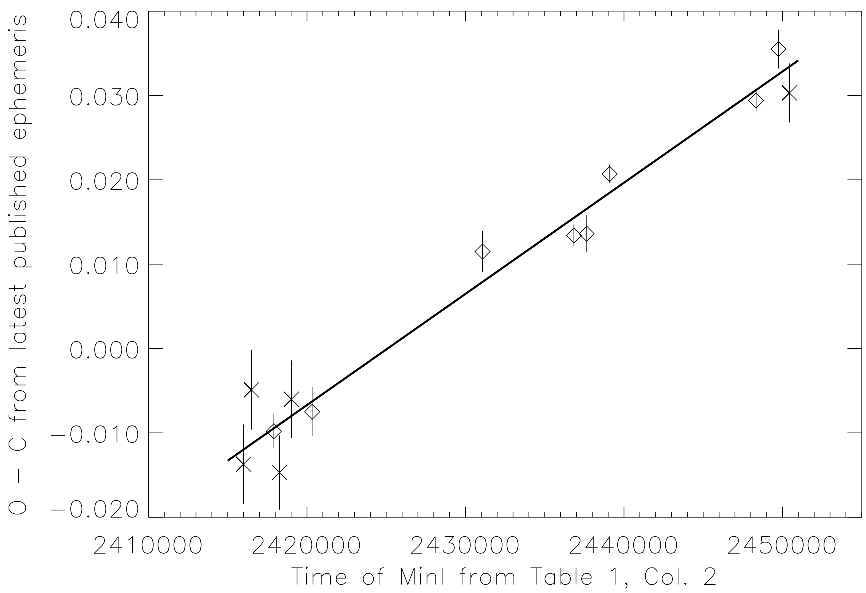

Figure 1. β Aur: O−C from the latest published ephemeris (Smith 1948) in days. The line represents the ephemeris of Eq. 1. Diamonds: $\sigma < 0.0030$, crosses: $0.0030 < \sigma < 0.0050$.

β Aur has been observed several times since 1900. The published values of the period, P, based on observations from the beginning of this century are close to 3.960000 days. The earliest works were reviewed by Baker (1910), who found $P = 3.960027 + 0.000010 \times (t - 1906)$ with an error of 0.000004 days. Later Berg (1936), as referred by Smith (1948), published the value $P = 3.960027 + 0.0000035 \times (t - 1906)$. The most recent period determination was carried out by Smith (1948) and yielded the ephemeris $MinI = 2431076.719 + 3.9600421 \times E$, with the error of P equal to 0.0000013. Smith concluded, that although the data indicated a slight increase in the period from 1900 to 1943 it would not be safe to infer that the period had changed. However Smith's ephemeris does not fit the later more accurate photoelectric observations.

Eq. 1 was obtained as follows: A preliminary mean period P_1 equal to 3.96004758 days was determined from all observational series. For spectroscopic observations the final times of MinI are determined using the SBOP code (Etzel 1985) assuming a period equal to P_1. Complete photoelectric light curves are published by Stebbins (1911), Johansen (1971) and ESA (1997). For these light curves phases have been calculated using P_1, and the final times of MinI were determined using the EBOP code (Etzel 1981) and the photometric elements found by Nordström and Johansen (1994). The orbit was assumed circular. For spectroscopic observations we chose an epoch close to the mean of the Julian dates where observations occurred, and for photoelectric observations we chose an epoch close to the mean of the Julian dates on which minimum observations have been obtained. Thus a wrong value of the period only introduces a scatter, not a systematic error in the times of MinI.

The 13 most accurate series were used to determine Eq. 1. Since the errors σ determined by SBOP and EBOP are internal and systematic errors probably exist, series with $\sigma <$ 0.0030 have been given equal weight 1, and series with $0.0030 < \sigma < 0.0050$ weight 0.5. The period, P, of Eq. 1 deviates so little from P_1 that a reduction with P would change the phase, ϕ, of any observation by ≤ 0.000014. The iteration has converged.

Table 1 and Fig. 1 give the results. The columns of Table 1 are: 1) Name of series. 2) Observed times of primary minimum found by means of the above-mentioned iterative procedure and found from the published data directly. We have also given the uncertainties σ determined by means of the SBOP, EBOP codes or the Kwee and van Woerden computations where these methods were applied. 3) Time interval, ΔT, of observation in JD$-$2400000. 4) $(O-C)_1$ from Eq. 1. 5) Epoch. 6) Comments. 7) References.

As a check we used SBOP to determine the actual period P_a and the radial velocity V_o of the center of mass for each spectroscopic series. If a third star exists, P_a and V_o are related. Several values of P_a deviate more than 2 σ from the period of Eq. 1. However, the values of V_o allow a maximum variation in P_a equal to 0.000087 ± 0.000022, showing that only for the Belo3 series P_a equal to 3.959973 ± 0.000021 could eventually be real.

We conclude that the period of β Aur is probably constant.

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PHOTOELECTRIC MINIMA OF ECLIPSING BINARIES

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The following table lists the unpublished photoelectric times of minima of several binaries observed at Mt. Suhora Observatory of the Cracow Pedagogical University after 1995. The observations were made using a double channel photometer (Kreiner et al. 1993), attached to the 0.6/7.5 m Cassegrain telescope. They were reduced in a usual way and left in the instrumental system (near to the UBVRI). The times of minima were determined using Kwee and van Woerden (KW) (1956) method or by parabola fitting (PF) or by Kordylewski's tracing paper (TP) (Szafraniec 1948) graphic method. The O−C values were computed using elements given in the General Catalogue of Variable Stars (IV edition) Moscow 1985-87.

Entries in all columns are self-explanatory.

Observers:

AP	Agata Piechnik
DM	Dragomir Marchev
EM	Ewa Mikołajczyk
MK	Martyna Kubacka
KK	Kinga Klimowicz
SZ	Stanisław Zoła
WO	Waldemar Ogłoza

Table 1

Star	Filters	HJD 2400000+	Error	O−C	Type	Method	Observer
SS Ari	B,V,R	50671.5356	±0.0002	−0.0371	Sec.	KW	WO
ZZ Aur	B,V,R,I	50423.6777	±0.0003	0.0108	Pri.	KW	AP, WO
	B,V,R,I	50457.3481	±0.0003	0.0131	Pri.	KW	AP, WO
	B,V,R,I	50458.2640	±0.0012	0.0272	Sec.	PF	AP, WO
TU Boo	B,V,R	50515.5518	±0.0004	−0.0763	Sec.	KW	EM, WO
	B,V,R	50516.5242	±0.0020	−0.0768	Sec.	PF	EM, WO
AT Cam	B,V,R,I	50425.5070	±0.0009	−0.0943	Pri.	PF	KK, WO
	B,V,R,I	50426.3090	±0.0008	−0.0900	Sec.	PF	KK, WO

Table 1 (cont.)

Star	Filters	HJD 2400000+	Error	O−C	Type	Method	Observer
RW Com	B,V	50563.4024	±0.0002	−0.0198	Pri.	KW	MK, WO
	V	50563.5239	±0.0005	−0.0172	Sec.	KW	MK, WO
CC Com	B,V,R	50157.5214	±0.0004	−0.0095	Sec.	PF	WO
GO Cyg	B,V,R	50670.5090	±0.0016	0.0566	Sec.	KW	WO
TW Dra	B,V,R,I	50673.4642	±0.0002	0.0225	Pri.	KW	WO
UX Her	B,V	50675.4206	±0.0011	0.0266	Pri.	PF	WO
	B	50627.4058	±0.0055	0.0261	Pri.	PF	WO
XY Leo	B,V,R	50100.4199	±0.0002	0.1131	Sec.	KW	SZ
	R	50114.4851	±0.0002	0.1154	Pri.	KW	SZ
	R	50114.6255	±0.0001	0.1138	Sec.	KW	SZ
	I	50152.4114	±0.0002	0.1149	Sec.	KW	SZ
	I	50152.5556	±0.0003	0.1170	Pri.	KW	SZ
	-	50482.4031	±0.0003	0.1286	Pri.	KW	SZ
	-	50482.5468	±0.0003	0.1297	Sec.	KW	SZ
SW Lyn	-	49680.5153		−0.0153	Pri.	KW	WO
	U,B,V	49736.5496	±0.0001	−0.0104	Pri.	KW	WO
	-	49762.3115		−0.0112	Pri.	KW	WO
	V	50411.5410	±0.0015	−0.0005	Pri.	TP	WO
BB Peg	B,V,R	50657.4575	±0.0002	0.0021	Pri.	KW	WO
	B	50671.3770	±0.0021	0.0040	Sec.	PF	WO
DI Peg	B,V,R	50672.4811	±0.0001	−0.0135	Pri.	KW	WO
TX UMa	R	49964.4596	±0.0011	0.1108	Pri.	KW	SZ
	-	50193.5288	±0.0002	0.1293	Pri.	KW	SZ
XY UMa	B,V,R,I	50422.6750	±0.0001	−0.0117	Pri.	KW	DM

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NSV 04493: AN RR LYRAE STAR IN LEO MINOR

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The variability of NSV 04493 (=CSV 006721 =GSC 2500.0189) was announced by Rigollet (1953), who indicated that this object was a Cepheid with a photographic magnitude variation from $13^{m}_{.}2$ to $14^{m}_{.}2$. In the NSV catalogue (Kholopov, 1982), no further information is given about this star.

As part of a surveillance program of poorly studied variable stars, NSV 04493 was occasionally observed in the B, V, R_c, and I_c bands with several different CCD and PEP systems (cf. Henden 1996 for details) from 3 May 1986 to 23 May 1993. In a collaborative observational program between the U.S. Naval Observatory Flagstaff Station and the Grup d'Estudis Astronomics, this object was intensely observed in the V band with the 0.4m Newtonian telescope at Monegrillo Observatory from 4 January to 9 February 1997, and in UBVRI bands with the 1.0m Ritchey-Cretien telescope at the USNO Flagstaff Station from 9 to 14 March 1997. Figure 1 shows the field of NSV 04493, and Table 1 lists the standard V magnitudes and color indices of comparison stars near the variable.

Table 1

Star	GSC	V	(U−B)	(B−V)	(V−R)	(R−I)
A	2500.0125	14.882±0.008	0.191±0.010	0.723±0.009	0.377±0.010	0.364±0.007
B	2500.0275	14.398±0.003	0.441±0.012	0.835±0.004	0.464±0.003	0.444±0.003
C	2500.0375	14.401±0.003	0.685±0.013	1.115±0.007	0.613±0.004	0.589±0.004
D	2500.0413	14.491±0.002	0.130±0.006	0.666±0.003	0.382±0.003	0.359±0.004
E	2500.0557	14.953±0.005	0.112±0.008	0.636±0.006	0.371±0.005	0.340±0.005
F	2500.1161	15.003±0.004	0.154±0.007	0.671±0.006	0.369±0.004	0.341±0.005
G	2500.1185	14.723±0.006	0.038±0.005	0.672±0.007	0.384±0.006	0.364±0.008

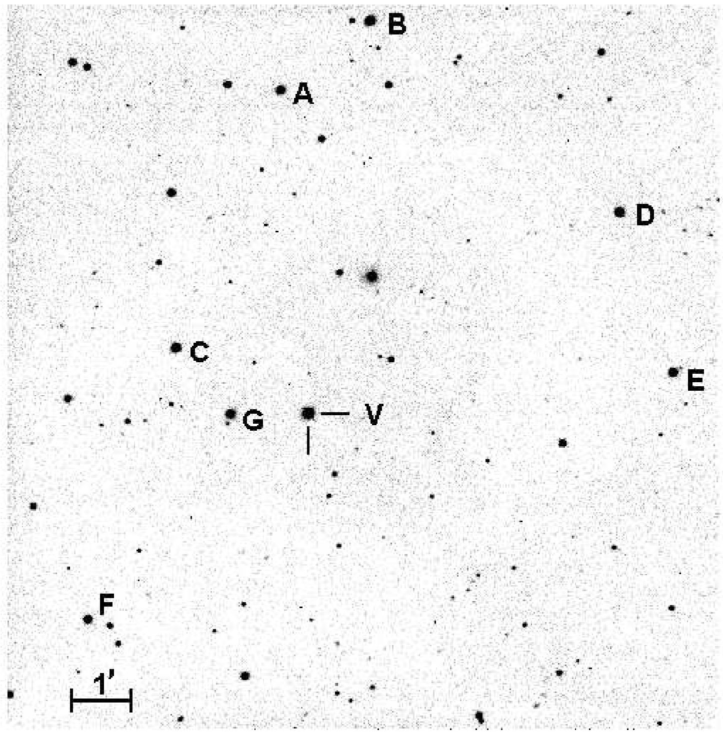

Figure 1. V=NSV 04493. North is on top

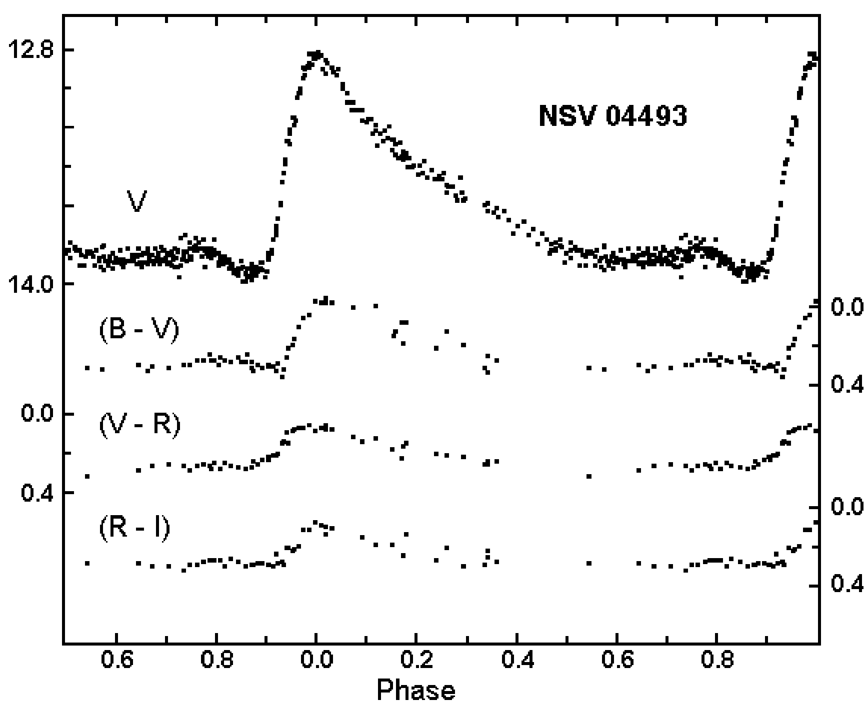

Figure 2.

The observations show that NSV 04493 is not a Cepheid but an RR Lyrae star with an asymmetric light curve (ϵ=0.13) and an amplitude of $1\overset{m}{.}1$ in V, from $12\overset{m}{.}85 \pm 0.03$ to $13\overset{m}{.}95 \pm 0.04$. Figure 2 displays V, B−V, V−R, and R−I light curves, and Table 2 lists B−V, V−R, and R−I amplitudes.

Table 2

	B−V	V−R	R−I
Amplitude	0.34±0.04	0.21±0.04	0.18±0.06

The following ephemeris in the V band was also computed:

$$\begin{array}{rl}\text{Max.} = \text{HJD}\,2450487.507 & + \; 0\overset{d}{.}526146 \times \text{E} \\ \pm 0.006 & \pm \; 0.000002\end{array}$$

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THE VARIABILITY TYPE AND PERIOD OF HD 143213

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The variability of HD 143213 = SAO 121294 = GSC 353-301 was discovered by the TYCHO instrument of the HIPPARCOS satellite (Makarov et al., 1994). Among the 103 usable measurements in the B_T and V_T photometric channels there were a few discordant (fainter) ones which indicated a possible eclipsing binary. The small number and unsuitable temporal distribution of them made any more definite statement impossible.

E. Born therefore made 310 visual magnitude estimates between June 1996 and August 1997, using 10×70 binoculars. This resulted in the classification of HD 143213 as an Algol-type variable with a period of 3.4500 days (±0.0003 days). The lightcurve constructed from Born's observations is displayed in Fig. 1. It is an Algol-type lightcurve with an eccentric secondary minimum. The primary and secondary minima are about 0.5 mag and 0.3 mag deep, respectively. The width of the minima is about $D = 0.2$ days. The secondary minimum is located at phase 0.545 (±0.006). The period was computed from 3 individual primary minima which were sufficiently well covered to determine precise timings, a conservative estimate of the uncertainty being 0.02 days in each case. The temporal distribution of the 310 observations is such that any period other than 3.45 days can be safely excluded. The ephemeris for primary minima is:

$$\mathrm{JD(min)} = 2450304.35\ (\pm 0.02) + 3.4500\ (\pm 0.0003) \times \mathrm{E}$$

Using this information, the TYCHO measurements were folded with the now known period. This resulted in the lightcurve shown in Fig. 2. It is a curious coincidence that the random scatters of the visual and the satellite measurements are almost the same. Both the character and the parameters of the variability derived from the visual estimates are fully confirmed by the TYCHO data. In particular, the relative phase of the secondary minimum (0.550 ±0.007) is identical. Unfortunately, there are only 3 measurements within a single primary minimum (made within 20 minutes), and 6 measurements within two different secondary minima. Obviously, this temporal distribution of the TYCHO measurements could not have allowed to derive a period. Also, it is not possible to derive the widths or precise locations of the minima from the TYCHO data. Nevertheless, the time difference between the two sets of secondary minimum points (103.99 periods, see Table 1) confirms the period to within 0.0002 days.

Despite the perfect agreement between the period and shape of the two lightcurves, there is a strong discrepancy in the phase. Usually, such a phase shift between two observational sets separated by a long time interval can be used to improve the period.

However, in the particular case of HD 143213 this turned out to be impossible. Any modification of the period to force the primary minima of both Born and TYCHO to be at about phase zero resulted in a very significant separation in phase of Born's 3 primary minima *and* of the 2 TYCHO secondary minima. Thus, any "improved" period was inconsistent with *both* sets of observational data. But, again, both sets agree on the period itself. It perfectly fits the two TYCHO secondary minima, as well as their separation from the one observed TYCHO primary minimum. And it also fits all data of Born (unambiguously; no alias periods are possible). This point is strengthened by the perfectly identical phase of the secondary minima in the two independent sets.

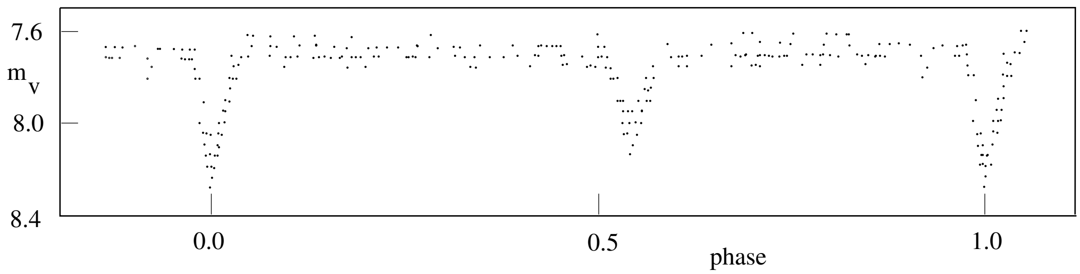

Figure 1. Visual light curve of HD 143213; 310 estimates folded with the period of 3.4500 days.

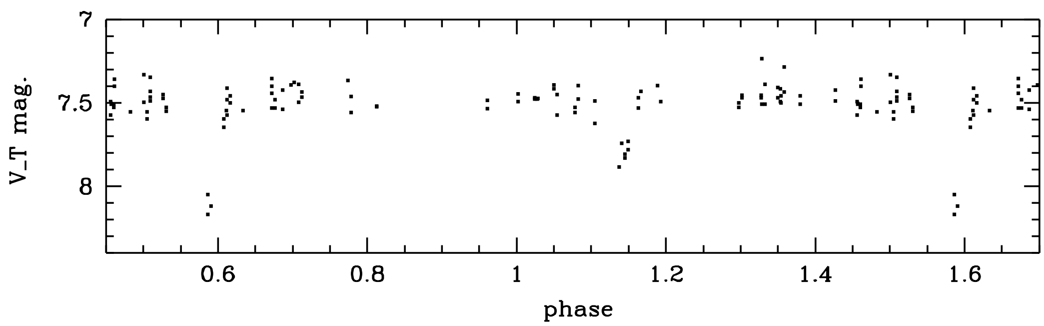

Figure 2. TYCHO lightcurve of HD 143213; 103 V_T measurements folded with the same period. Note the phase shift of about 0.59.

The second problem is that it is not obvious *which* period should be used, since the TYCHO minimum is at phase 0.59. So, should a period modification shift it to phase 0.0 or to phase 1.0? In other words, should a slight increase or a slight decrease of the period be applied? There is no way to decide which is better (actually, both are equally bad, as explained above). Thus, in addition to contradicting the data, a correspondingly changed period would be ambiguous.

These arguments led us to the conclusion that the discrepancy cannot be resolved with the existing data. We decided to publish this intermediate result rather than to wait for years until the discrepancy can be solved by us. The publication will surely ease the case for other observers, and give them a guide on what to do. To this end, we give the existing timings in Table 1.

Observations in the visibility periods 1998 and 1999 or data from sky patrol plate archives will resolve the discrepancy. Table 1 will allow to combine such data with TYCHO and/or Born, and thus to see where the cause might be. It could be in the observations or in the star. On one hand, a real phase shift of about a day within 7 years is somewhat unlikely. But, on the other hand, the observational data are very clear.

Table 1

BJD	E	Comment
2450304.35	0.00	min. I from vis. obs. (± 0.02 d)
2450604.50	87.00	min. I from vis. obs. (± 0.02 d)
2450649.35	100.00	min. I from vis. obs. (± 0.02 d)
2450606.37	-	min. II from vis. obs. (± 0.03 d)
2450637.39	-	min. II from vis. obs. (± 0.03 d)
2448257.072	−593.41	TYCHO obs. at min. I magnitude
2448257.072	−593.41	TYCHO obs. at min. I magnitude
2448257.087	−593.41	TYCHO obs. possibly on the rising branch
2447907.100	-	TYCHO obs. at min. II magnitude
2447907.100	-	TYCHO obs. at min. II magnitude
2447907.114	-	TYCHO obs. possibly on the rising branch
2447907.114	-	TYCHO obs. possibly on the rising branch
2448265.873	-	TYCHO obs. at min. II magnitude
2448265.887	-	TYCHO obs. possibly on the rising branch

Acknowledgements: We thank Andreas Wicenec, ESO Garching, for help with the retrieval of the TYCHO data.

Reference:

Makarov, V., et al., 1994, *IBVS*, No. 4118

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OPTICAL PROPERTIES OF HD 154791 DURING X-RAY OUTBURSTS

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Garcia et al. (1983) identified the *Ariel V* X-ray source 2A 1704+241 ($\equiv$ 4U 1700+24 $\equiv$ 3A 1703+24) with the bright star HD 154791. They argued for the object to be a binary in which the M giant is orbited by a neutron star. According to Garcia et al. the main characteristics of HD 154791 are: i) significant variations in the X-rays on time scales from minutes to years; ii) lack of detectable continuum in the IUE SWP spectra and presence of C IV 1550 Å and N V 1238 Å in emission; iii) absence of significant variations in optical and infrared photometry; iv) the M giant optical spectrum is not contaminated by emission lines tracing the presence of the hot companion.

Simultaneous X-ray, IUE and optical observations in March 1985 were reported by Dal Fiume et al. (1990). They confirmed the identification of 2A 1704+241 with HD 154791 and noted some changes in comparison to the observations of Garcia et al. (1983). Dal Fiume et al.'s X-ray observations are characterized by a much softer spectrum and by an overall decrease of the source intensity by a factor of $\sim$6. The high excitation UV emission lines of C IV and N V had disappeared.

Recently Remillard (1997, announcement circulated through the VSNET-Alert electronic service) reported about an X-ray outburst of HD 154791. During the first two weeks of November 1997 the flux at 2-10 keV reached a historical maximum of about 35 mCrab.

Being one of the very few binaries supposed to harbor an M giant and a neutron star, HD 154791 is in on our long-term observing program. A few days before and a few ones after Remillard's announcement of the X-ray outburst we secured high-resolution CCD spectra of HD 154791 with the Coudé-spectrograph of the 2 m telescope of the National Astronomical Observatory Rozhen (resolution $R \sim 0.35$ Å) and with the Echelle ($R \sim 0.3$ Å) spectrograph of Padova & Asiago Astronomical Observatory 1.82 m telescope. With the Boller & Chivens ($R \sim 18$ Å) spectrograph at the same telescope we secured also low resolution spectrophotometry. Photometric observations have been obtained with the UBVRI photoelectric photometer at the 60 cm Cassegrain telescope of Torun Observatory (Poland). SAO 84893 and δ Her have been used as comparison and check star respectively. The intrinsic errors in the BVRI bands do not exceed $0\overset{m}{.}01$ and for the U data they are typically between $0\overset{m}{.}02$ and $0\overset{m}{.}04$. The photometric data and spectra closest in time to the X-ray outburst are presented in Table 1 and Figure 1 respectively. A few additional spectroscopic data are given in Table 2.

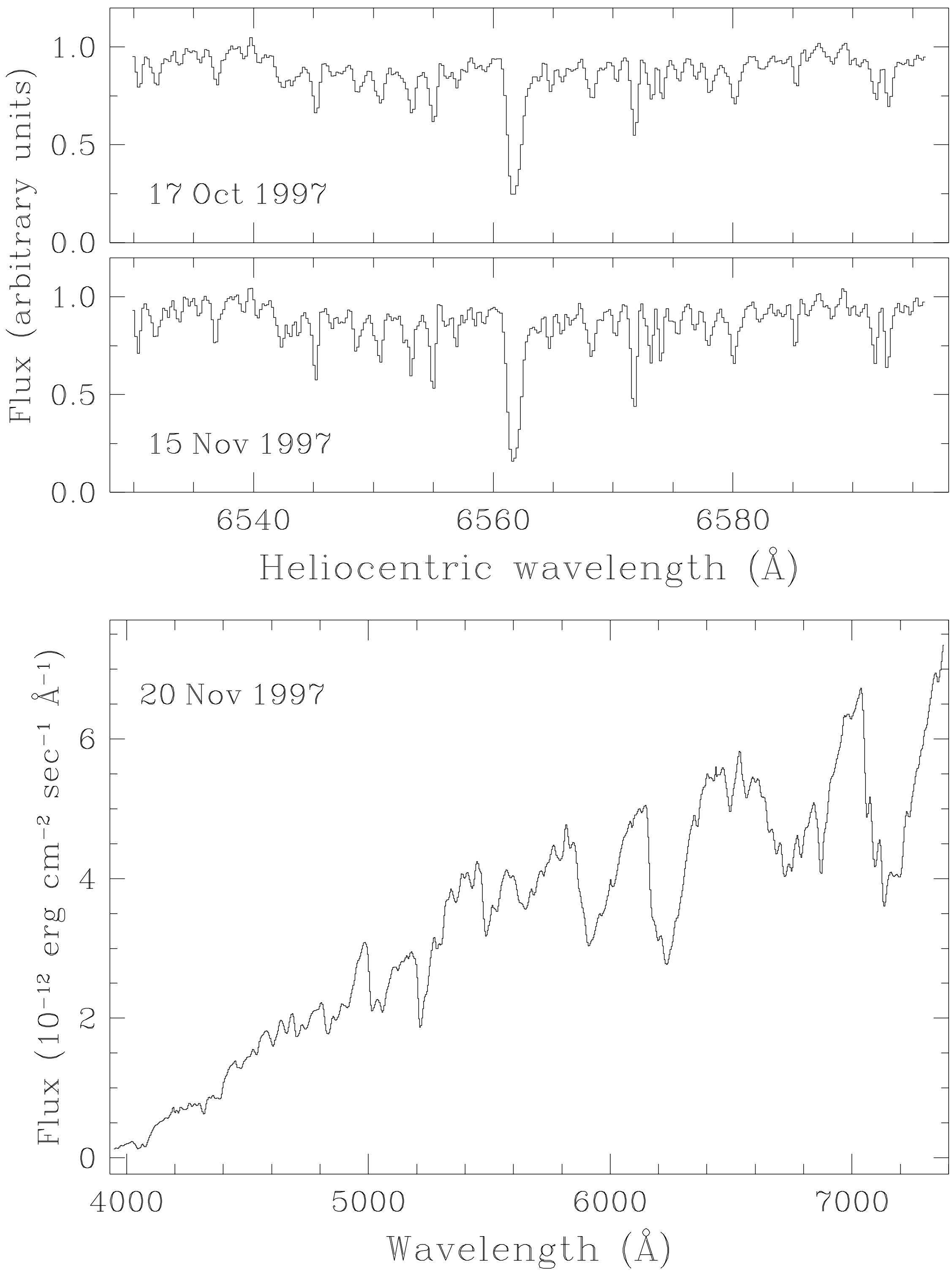

Figure 1. The Hα region in the high-resolution spectra of HD 154791, obtained on 17 October 1997 (Rozhen) and 15 November 1997 (Asiago), i.e. soon before and near maximum of the X-ray outburst. The spectra are normalized to the local continuum level (*two upper panels*). Flux calibrated low-resolution spectrum of HD 154791 obtained on 20 November 1997 (Asiago) (*bottom panel*)

The main result of the present investigation is that the X ray outburst, still ongoing at the time of our November observations, had no detectable effect on the optical properties of HD 154791.

No changes in the high resolution spectra are visible, and no emission line appeared in the Hδ–Hα region. The numerous absorption lines visible in the spectra of Figure 1 are normal in M giants and are produced by neutral metals. The radial velocities in Table 2 confirm the Garcia et al. (1983) report of undetectable orbital motion, either caused by low orbital inclination or by large orbital separation. The Hα equivalent width values presented in Table 2 are constant within the measurement errors. The overall aspect of the low resolution spectrum in Figure 1 is still and always that of an M giant.

The photometric data show that there are no variations in the BVRI bands, even if variability in the U band is present. Our data seem to ascribe the latter to a sort of flickering activity. Our pre-X-ray-outburst photometry shows the star about $0\overset{m}{.}26$ fainter in B and $\sim 0\overset{m}{.}14$ brighter in V in comparison to Garcia et al. (1983).

Table 1. UBVRI photometric observations of HD 154791

Date	JD 2400000+	V	U−B	B−V	V−R	V−I
16 Aug 1997	50677.474	7.64	2.13	1.73	1.35	2.68
17 Aug 1997	50678.377	7.67	1.66	1.74	1.36	2.71
19 Aug 1997	50680.391	7.66	1.82	1.76	1.36	2.63
20 Aug 1997	50681.425	7.67	1.29	1.72	1.37	2.65
25 Aug 1997	50686.355	7.64	1.76	1.74	1.37	2.62
21 Oct 1997	50743.264	7.65	1.68	1.76	1.33	2.64

Table 2. The radial velocity of the absorption lines and the equivalent width of Hα measured in our high-resolution spectra

Date	JD 2400000+	$RV_\odot$ km s^{-1}	W_λ Å
1 Apr 1996	50175.493	-43.3 ± 0.4	0.97
3 May 1996	50207.402	-51.8 ± 0.5	1.00
3 Jun 1996	50238.395	-43.5 ± 0.4	1.01
17 Oct 1997	50739.178	-46.7 ± 0.5	0.98
15 Nov 1997	50768.216	-49.9 ± 0.5	1.04
18 Nov 1997	50771.193	-52.8 ± 0.4	1.08

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PHOTOSPHERIC AND CHROMOSPHERIC ACTIVITY OF THE BRIGHT AND SINGLE G5 DWARF HR 4864 = HD 111395

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Stars similar to our Sun are an important test field for the deeper understanding of solar physics. So it is no surprise that much effort has been put into the study of magnetic activity of these stars culminating in the still ongoing, long-term Mt. Wilson H&K project initiated by the late Olin C. Wilson in the sixties. However, there is a real problem finding solar twins, i.e. stars that exactly match the Sun's astrophysical parameters (see, e.g., the annual Lowell workshops) and even if stars are found with only approximate solar parameters they are usually faint and not easily accessible for high-resolution spectroscopy. In this paper we draw attention to a single and bright G5 dwarf that deserves further high-resolution monitoring.

Table 1. NSO and KPNO radial velocities (for HJD 2,450,000+, in km s^{-1})

HJD	v_r	σ	Obs.	HJD	v_r	σ	Obs.	HJD	v_r	σ	Obs.
432.037	–8.6	1.3	NSO	439.022	–6.4	1.3	NSO	541.815	–10.8	0.75	KP
433.022	–9.6	1.2	NSO	441.032	–8.7	1.2	NSO	548.729	–9.2	0.37	KP
434.028	–8.4	1.2	NSO	442.036	–5.7	1.7	NSO	549.881	–8.9	0.39	KP
435.040	–8.5	1.2	NSO	447.016	–7.2	1.3	NSO	550.903	–9.3	0.39	KP
436.057	–10.2	1.5	NSO	448.024	–9.1	1.4	NSO	553.824	–9.0	0.48	KP
437.062	–10.0	1.5	NSO	451.027	–8.4	1.5	NSO	554.831	–9.1	0.49	KP
438.023	–9.5	1.6	NSO	458.018	–7.0	1.3	NSO				

Spectroscopic data were obtained in April 1997 at KPNO using the coudé feed telescope with camera 5, grating A, the long collimator and the 3k×1k F3KB CCD. This set up allows a resolution of $R = 35,000$ in the red wavelength regions and $R = 30,000$ in the blue. The summation of several short exposures enables a S/N ratio of close to 800:1 for the red spectra and approximately 300 for the Ca II H&K spectra centered at 3950 Å. Earlier 6420-Å spectra were obtained in December 1996 with the NSO McMath telescope and the stellar spectrograph at a resolution of 40,000 and varying S/N of 150–200:1. Table 1 presents 20 new radial velocities for HR 4864 that were obtained from cross correlations of the entire HR 4864 spectra with spectra of the IAU radial velocity standards β Gem, 16 Vir, and α Ari. These data indicate a constant velocity of –8.7±1.3 km s^{-1} in good agreement with earlier data by Beavers & Eitter (1986) and Duquennoy et al.

(1991) who found average velocities of −8.6 and −9.1 km s^{-1}, respectively. It seems now safe to say that we can exclude any binarity for HR 4864.

Figure 1 shows three interesting spectral regions of HR 4864; the 6420-Å region with several unblended photospheric absorption lines (a region that is frequently used for Doppler imaging), a spectrum of Hα, and a spectrum including the two Ca II resonance lines at around 3950 Å. Cross correlations of the many weak and moderately-strong photospheric lines (residual intensity above 0.6) showed an average FWHM of 0.123±0.002 Å, and with the calibration of Fekel (1997) this value relates to a projected rotational velocity $v \sin i$ of 2.9±0.4 km s^{-1} (adopting a radial tangential macroturbulence velocity of 3 km s^{-1}). A comparison of the overall spectral appearance of HR 4864 in the 6340–6600 Å wavelength region is in very good agreement with its G5V classification from prism spectra at 75 Å/mm by Harlan & Taylor (1970). The only significant disagreement is the Fe I 6430/Fe II 6432 line ratio (Figure 1, upper panel) that indicates a more solar-like temperature (G1 to G2) rather than G5. However, the singly-ionized line may overlap with an (unresolved) water vapor line at exactly the same wavelength. Also, Eggen (1978) mentioned a slight overabundance of iron relative to the Sun, [Fe/H]=+0.2, which could affect the observed B−V color and thus the line ratio versus $T_{\rm eff}$ calibration.

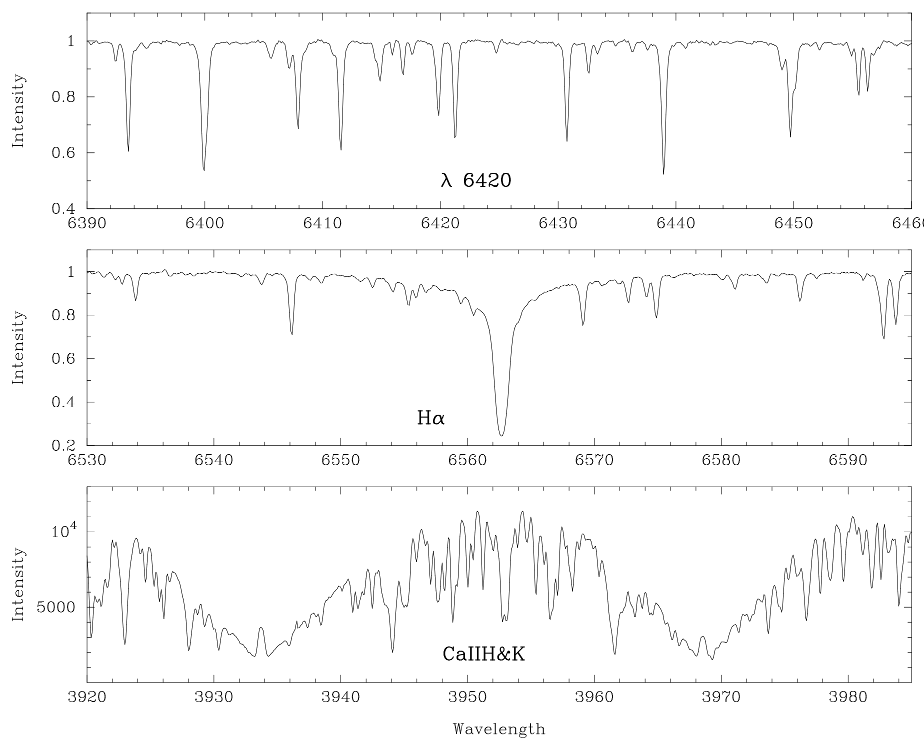

Figure 1. KPNO spectra of HR 4864 for three spectral regions of interest. From top to bottom: photospheric lines near 6420 Å, Hα, and Ca II H&K. Note the core emission at the bottom of the Ca resonance lines typical for chromospherically active stars

The Hα line appears like a normal absorption feature with line wings typical for a G-dwarf slightly cooler than the Sun. A comparison with spectra of other G dwarfs (not obtained with the same equipment though) indicates very small filling in of the line core, but this needs to be confirmed with higher resolution data.

Our single Ca II spectrum in Fig. 1 clearly shows emission in the cores of the H and K lines. In a G5V star we interpret these due to an active chromosphere. Their emission strengths significantly exceed the line strength seen in solar plage regions of the active Sun. Using the calibration of Linsky et al. (1979) and V−R=0.54 we measure an absolute emission surface flux in the H and K lines of 2.1×10^6 and 2.2×10^6 erg cm^{-2}s^{-1}, respectively.

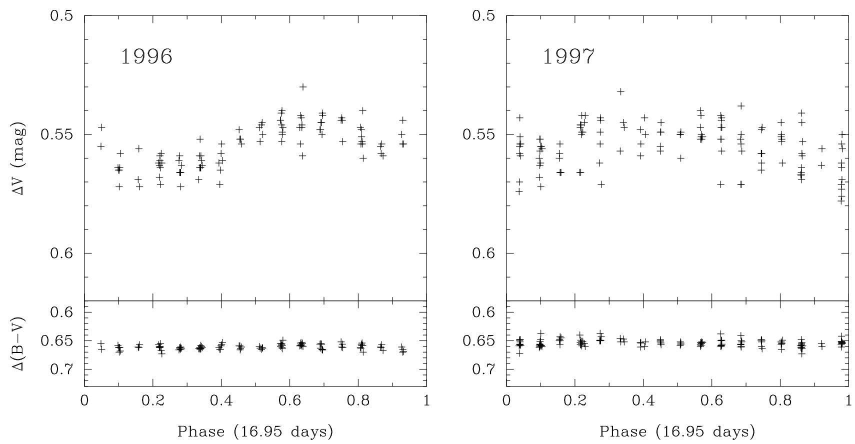

Figure 2. Seasonal V and B−V light and color curves of HR 4864. The 1996 light curve combines 53 consecutive nights starting at JD 2,450,212 while the 1997 data cover 92 consecutive nights beginning at JD 2,450,429

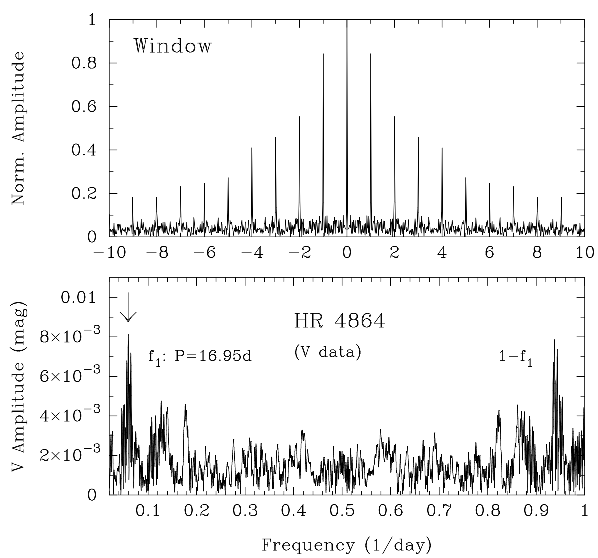

Figure 3. Periodogram from the combined 1996 and 1997 V-band photometry. The data indicate a best-fit frequency at $f_1 = 0.059$ cycles/day corresponding to a period of 16.95±0.50 days.

Continuous photometry of HR 4864 has been carried out with one of the University of Vienna twin APTs at Washington Camp in southern Arizona (Strassmeier et al. 1997) since early 1996 and a first light curve was presented in that paper. Here we analyse this data and present additional BV-photometry from 1997 (Figure 2). The comparison and check stars were HD 111469 (V=5.78, B−V=0.03 mag) and HD 111812 (V=4.94, B−V=0.67 mag), respectively. All readings incorporated a 2.5-mag neutral-density filter.

Figure 3 shows the periodogram and the window function for all available V data of HR 4864. A single period of 16.95±0.50 days gives the largest reduction of the squared residuals and we interpret this period as the rotation period of the star. In 1996 the light curve was nearly sinusoidal with a full peak to peak V amplitude of just 0.019±0.003 mag, while in 1997 the light curve appeared to have significantly changed in amplitude at around JD 2,450,500 from 0.025 mag before to 0.015 mag thereafter.

The Hipparcos catalog (ESA 1997) lists HR 4864 with a V magnitude of 6.29, and B−V=0.703 mag and a parallax which implies a distance of 17.2 pc. The absolute visual brightness is thus +5.1 mag in perfect agreement with the tabulated brightness of a G5V star according to Gray (1992). The expected B−V color, on the other hand, is 0.672 mag and our measured B−V was 0.690±0.003 (std) mag in 1996 and 0.680±0.003 (std) mag in 1997. The decrease of 0.01 mag is barely significant but still noticeable in Figure 2 and could be attributed to overall changes of the starspot activity.

Our new measure of $v \sin i = 2.9 \pm 0.4$ km s^{-1} and $P_{\rm rot} = 16.95 \pm 0.50$ days determines the minimum stellar radius to $R \sin i = 0.97$ R$_\odot$. The nominal radius of a G5V star is tabulated as 0.96 R$_\odot$ (e.g. Gray 1992). HR 4864 is thus seen almost equator-on, i.e. $\sin i \approx 0.988$ or $i \approx 81°$.

With all these parameters known, HR 4864 might also be a good candidate to search for further extra-solar planets by means of high-precision radial velocities or eclipse techniques and could eventually help to resolve the 51 Peg debate.

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PG 2337+300: A NEW CATACLYSMIC VARIABLE

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The star PG 2337+300 was identified as an ultraviolet excess source by the Palomar-Green survey (Green, Schmidt & Liebert 1986). It was given the spectroscopic designation "sd" (subdwarf), presumably based on a low signal to noise spectrum showing some moderately broad Balmer absorption lines. Wesemael et al. (1992) classified the star as a B-type subdwarf on the basis of Strömgren system photometry ($y = 13.91$, $b - y = 0.06$, $u - b = 0.127$, $m_1 = 0.06$).

PG 2337+300 was observed for three hours with the two-channel Louisiana State University Photometer attached to the 0.9m telescope at McDonald Observatory (Fort Davis, Texas). The observations commenced on JD 2450752.6996 (October 31.195, 1997), and consisted of a continuous sequence of 10 second integrations, with occasional interruptions to measure the sky background brightness. No filter was used (in order to maximise the count rate) and the effective bandpass is roughly similar to Johnson B, though broader. The observations are plotted in the top of Figure 1. Simultaneous measurements of a comparison star, made with the second channel of the photometer, showed a flat light curve with $\sigma = 0.008$ mag.

A spectrum of PG 2337+300 (exposure time of 45 minutes) was obtained JD 2450756.6677 (November 4.167, 1997) with the 2.7m telescope at McDonald Observatory using the Large Cass Spectrograph, a 600ℓ/mm grating (blazed at 4200 Å), and the TI1 800×800 CCD. This particular grating/detector combination yields a spectral resolution of ≈ 3.5 Å (FWHM). The spectrum (normalized to its continuum fit) is shown in the bottom of Figure 1. The Balmer lines (Hβ to H9) have broad line wings in absorption and sharp emission cores. In addition, there is a HeI absorption line at 4471 Å and an emission line at ≈ 4650 Å probably due to C III/N III.

The irregular photometric variations with a typical timescale of a few minutes, the blue colour, and the emission lines provide unmistakable evidence that PG 2337+300 is a cataclysmic variable and not a normal subdwarf B.

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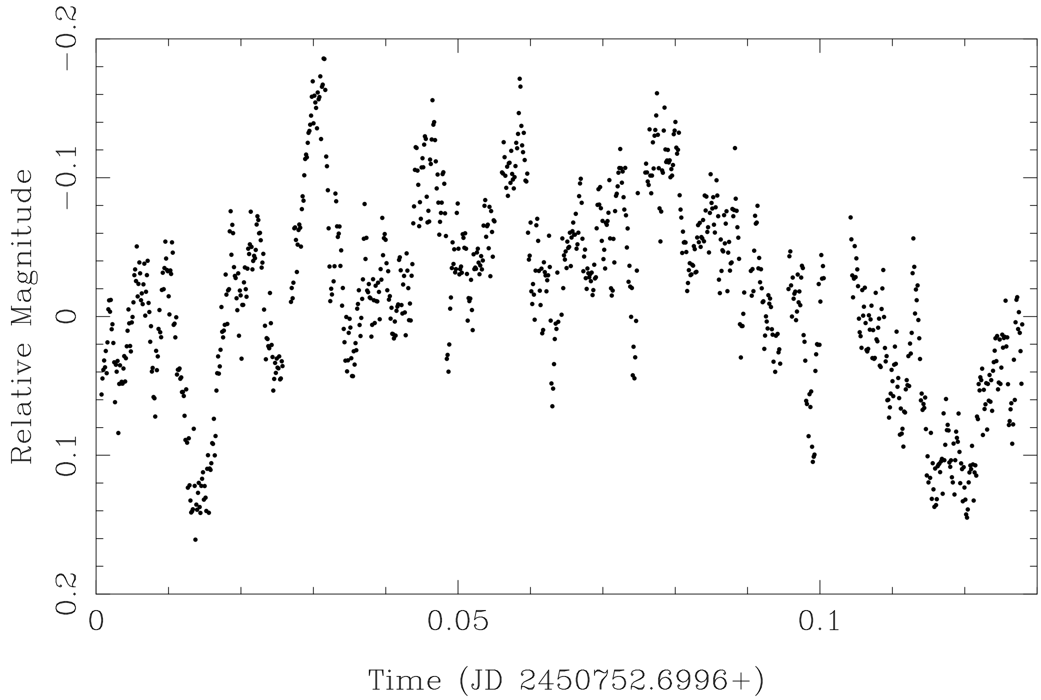

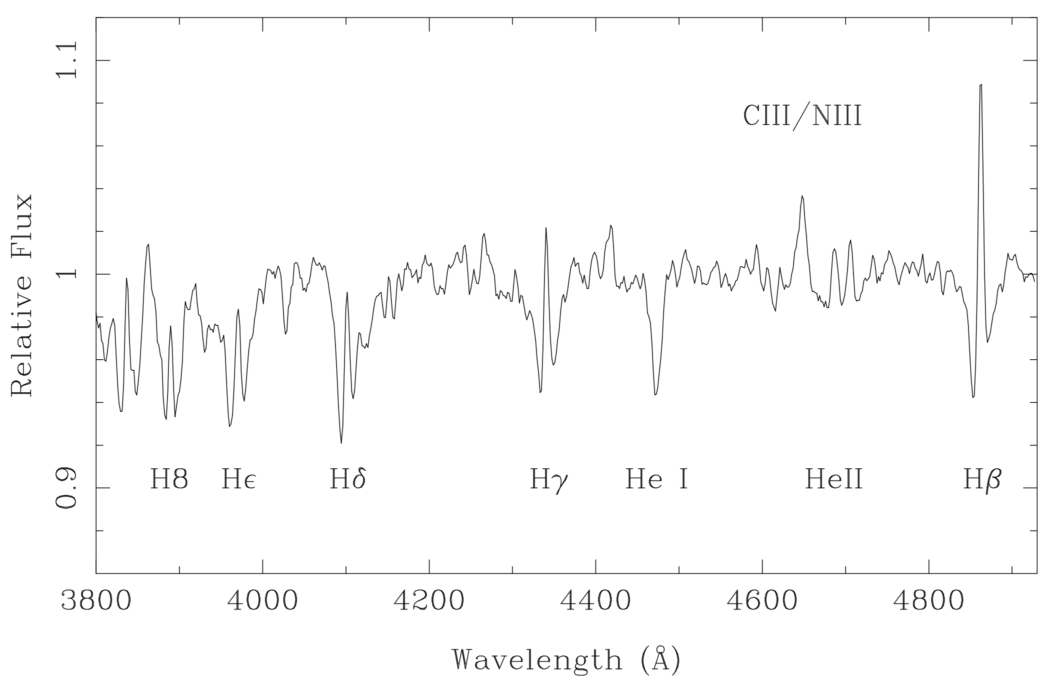

Figure 1. Top: High speed photometric observations of PG 2337+300 from October 31, 1997. Bottom: The normalized spectrum of PG 2337+300. The signal-to-noise ratio is ≈ 30 near Hβ and ≈ 20 near H8.

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VARIABILITY OF GSC 1062-33 AND GSC 1062-92

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We report on the discovery of brightness variations of the stars GSC 1062-33 and GSC 1062-92. The former is an Algol-type eclipsing binary with a period of 1.6 days; the latter seems to be a pulsating variable with a period of about 26 days.

The variability of GSC 1062-33 was discovered by K. Bernhard with his private 8-inch reflector and CCD camera after about half a year of systematic search for new variables close to very bright stars (Altair in this case). On September 18, 1997 the star was found about half a magnitude brighter than a few days before. Follow-up measurements by the discoverer and W. Quester quickly revealed the nature and period of the variability. Figure 1 shows the resulting Algol-type lightcurve after folding according to the ephemeris

$$\mathrm{JD(min\ I)} = 2450749.295\ (\pm 0.001) + 1.6160\ (\pm 0.0008) \times E$$

These lightcurve elements were derived by weighted least-squares adjustment to the 7 primary minima listed in Table 1. The period is unambiguously determined in spite of the short observing season before the star got lost in the evening twilight. No aliases or multiples are possible, and periods shorter than 1.6 days are excluded by the total length of primary plus secondary minima. The depths of the primary and secondary minima in the unfiltered CCD band are about 0.52 mag and 0.11 mag, respectively. A series of CCD observations by S. Kiyota (minimum no. 7 in Table 1) shows that the primary minimum is about 0.1 mag deeper in the V band than in the unfiltered CCD band. The widths of both minima are around $D = 8$ hours or 0.21 periods; no phase of constant minimum light exists. Within the uncertainties of the observations, the secondary minimum is symmetric at phase 0.5.

Figure 1 displays relative magnitudes, with the different instrumental scales (for details see Table 1) shifted to give zero at the star's maximum light. In the GSC magnitude scale (IIaD plates), the brightness of the star is between 10.5 and 11. All observations shown in Figure 1 used several neighbouring GSC stars as reference. Crosses are data from K. Bernhard, circles from W. Quester.

In the course of the follow-up observations for GSC 1062-33, W. Quester noticed that the immediately neighbouring star GSC 1062-92 (0.6 arcmin to the south-west) had slowly

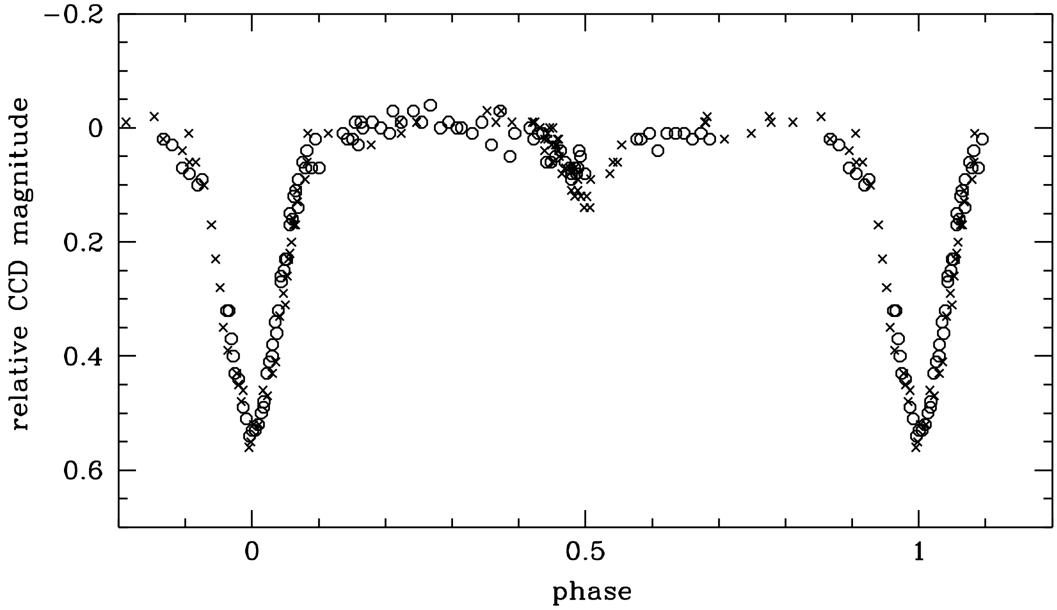

Figure 1. Folded lightcurve of GSC 1062-33.

Table 1

Primary minima of GSC 1062-33 between September 10 and November 8, 1997. Observers are: B = Klaus Bernhard, 20cm Schmidt-Cassegrain, CCD camera Starlight SX unfiltered; Q = Wolfgang Quester, 20cm Cassegrain, CCD camera ST-7 with filter KG5/2; K = Seiichiro Kiyota, Tsukuba, Japan, 25cm Schmidt-Cassegrain, CCD camera Bitran BT-20 with Johnson V filter. Minima nos. 2, 4, 5 and 7 were only partly observed. The minimum times for these four cases were determined by fitting the observed rising/declining branches to the shape of the completely observed minima. This is duly reflected in the assigned timing uncertainties. The uncertainty of minimum no. 1 (the single discovery exposure) was conservatively set to one quarter of the total eclipse width.

No.	BJD		E	Obs.	Comment
1	2450702.415	±0.08	−29	B	single exposure
2	2450715.36	±0.04	−21	B	rise
3	2450728.28	±0.01	−13	B	min. plus rise
4	2450741.235	±0.01	−5	Q	rise
5	2450744.37	±0.04	−3	Q	decline
6	2450749.295	±0.001	0	Q	complete
7	2450758.98	±0.02	6	K	decline

faded by more than 0.1 mag over a time interval of about 10 days. On request, K. Bernhard confirmed the variability by checking his own CCD frames of the field. The nightly series of exposures for the neighbouring Algol variable revealed no quick variations of GSC 1062-92. Thus, we present in Figure 2 the daily means of the available observations.

They allow no definitive statement about the variability type and lightcurve elements, but they strongly point to GSC 1062-92 being a pulsational variable with a period of about 26 days and an amplitude of the order of 0.15 mag. Figure 2, like Figure 1, shows relative CCD magnitudes (the GSC magnitude of GSC 1062-92 is between 11.5 and 12.0). Symbols are as in Figure 1. The tick marks above and below the data points indicate the times of maxima and minima of the suggested 26-day pulsations.

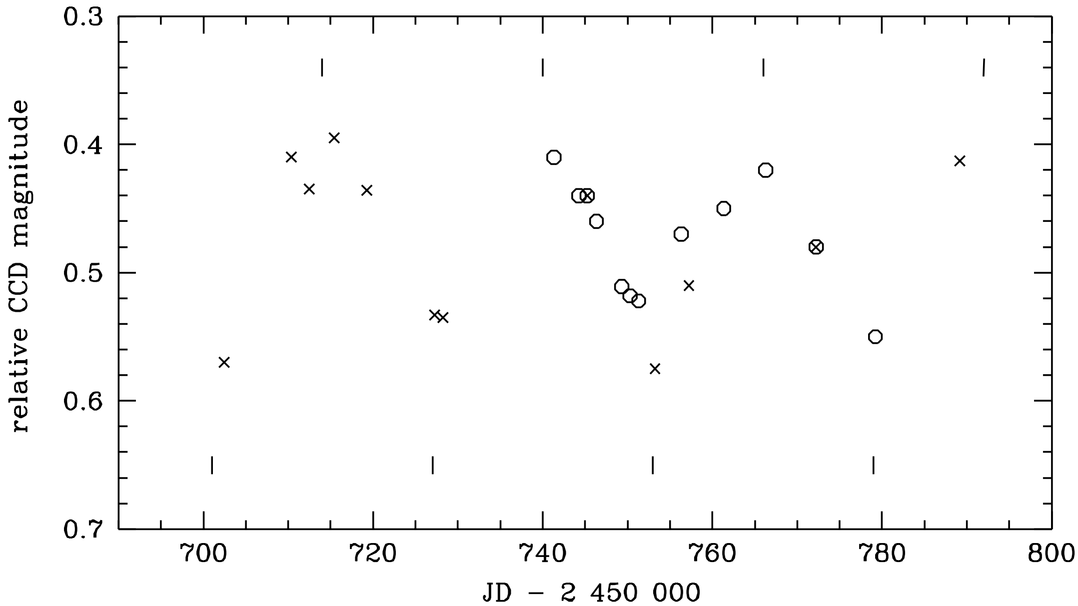

Figure 2. Lightcurve of GSC 1062-92 from September 10 to December 6, 1997.

For both newly-discovered variables, GSC 1062-33 and GSC 1062-92, definitive lightcurve elements can in principle be derived during the observing season 1998.

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ON THE VARIABILITY OF EARLY A-TYPE SUPERGIANTS

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Lucy (1976) performed an harmonic analysis of the radial velocities of the A2Iae supergiant Deneb (α Cyg = HR 7924 = HD 197345), especially those of Paddock (1935), which indicated that this star pulsated in 16 different modes with periods between 6.9 and 100.8 days. Photometry by Fath (1935) showed definite variability with an amplitude of 0.05 mag. The photometric and radial velocity variations may be correlated. Radial velocity measurement sets exist for a number of early A supergiants, but there are no extensive data sets obtained in any modern photometric system. This is somewhat surprising as these are among the brightest stars in our Galaxy and similar stars are seen in other nearby spiral galaxies.

With the photometry from the Hipparcos satellite (ESA 1997), we have examined the Hipparcos data from Deneb and other A0 to A5 supergiants included in the 5th edition of the Bright Star Catalogue (Hoffleit & Warren 1991). Table 1 contains for each star the stellar identifications (Name, HR, HD, and HIP numbers), the spectral type, the number of transits which were photometrically accepted, the mean magnitude in the Hipparcos photometric system, the standard error of this magnitude, the amplitude which we take to be the difference between the 95th percentile and 5th percentile magnitudes, and any period which is given. The amplitudes and standard errors are correlated although there may be slightly different relations for Ia and Ib stars.

Figure 1 shows the standard errors plotted against the Hipparcos photometric mean magnitudes with the values for the Ia stars indicated by plus signs, Iab stars by open diamonds, and Ib stars by crosses. The photometric amplitudes of the Ia stars are greater than those of the Ib stars with the Iab stars intermediate. This result confirms Maeder (1980)'s conclusion that for supergiants of any spectral type the amplitudes increase with luminosity. His peak-to-peak amplitudes for A0-A9 stars are 0.051 and 0.039 mag for spectral types Ia and Ib, respectively, results similar to those in Table 1. Further Deneb, the brightest early A supergiant, has an amplitude of variability similar to those of other Ia stars.

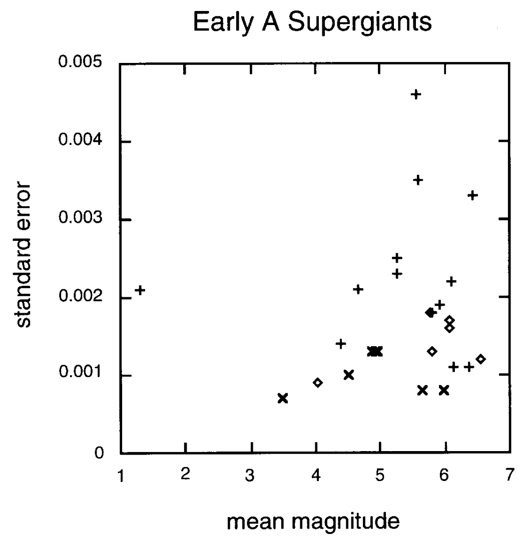

Figure 1. The standard errors of the Hipparcos photometry of A0 to A5 supergiants as a function of Hipparcos magnitude. The standard errors are correlated with the amplitudes of variability. Plus signs represent luminosity class Ia stars, open diamonds class Iab stars, and crosses luminosity class Ib stars

Table 1: Stellar and Photometric Parameters

Name	HR Number	HD Number	HIP Number	Spectral Type	Accepted Transits	Mean mag. (mag.)	Standard Error (mag.)	Amplitude (mag.)	Periods (days)
	618	12953	9990	A1 Iae	122	5.8124	0.0018	0.06	6.36100
	641	13476	10379	A3 Iab	103	6.5633	0.0012	0.05	
9 Per	685	14489	11060	A2 Ia	128	5.2723	0.0025	0.07	
	825	17378	13178	A5 Ia	123	6.3677	0.0011	0.04	
	964	20041	15192	A0 Ia	102	5.9277	0.0019	0.05	
	1040	21389	16281	A0 Iae	78	4.6710	0.0021	0.04	
	2074	39970	28154	A0 Ia	125	6.1182	0.0011	0.05	
13 Mon	2385	46300	31216	A0 Ib	44	4.5019	0.0010	0.02	
	2874	59612	36431	A5 Ib	116	4.9210	0.0013	0.03	
3 Pup	2996	62623	37677	A2 Iabe	165	4.0152	0.0009	0.03	
30 Leo	3975	87737	49583	A0 Ib	98	3.5034	0.0007	0.03	
	4144	91533	51623	A2 Iab	113	6.0751	0.0016	0.06	
	4169	92207	52004	A0 Iae	106	5.5513	0.0046	0.11	1.33238
	4228	93737	52827	A0 Ia-Iab	122	6.0714	0.0017	0.08	
	4438	100198	56201	A3 Iae	127	6.4184	0.0033	0.14	
o^2 Cen	4442	100262	56250	A2 Ia	126	5.2534	0.0023	0.05	
	4541	102878	57741	A2 Iab	140	5.7611	0.0018	0.06	
	4563	103516	58103	A3 Ib	137	5.9641	0.0013	0.04	
	4578	104035	58427	A3 Ib	140	5.6577	0.0008	0.03	
	4876	111613	62732	A2 Iabe	174	5.8116	0.0013	0.06	
ι^2 Sco	6631	161912	87294	A2 Ib	72	4.8648	0.0013	0.05	
	6825	167356	89470	A0 Ia	74	6.1064	0.0022	0.05	2.35950
42 Cyg	7835	195324	101067	A1 Ib	162	5.9906	0.0008	0.03	
Deneb	7924	197345	102098	A2 Iae	110	1.2966	0.0021	0.07	
10 Cep	8334	207260	107418	A2 Ia	115	4.3911	0.0014	0.05	
6 Cas	9018	223385	117447	A3 Iae	138	5.5888	0.0035	0.09	

Figure 2 shows the light curve for Deneb. Those of the other A-type supergiants in Table 1 are similar. It is very difficult to determine periods with methods such as the Scargle periodogram as the way the stars' magnitudes were sampled is not consistent with the assumptions of the mathematic methods. One can deduce evidence for a period of order two weeks, but without more complete light curves the results are open to question. It is unclear whether for Deneb the periods found with more complete light curves will in fact be those deduced by Lucy. These periods and their relative contributions contain information about the hydrodynamics of the stellar atmosphere. How they change from location to location in the HR diagram or equivalently how they change as the stars evolve is unknown.

The light curve of Deneb and those of the early A supergiants examined demonstrate that such stars are relatively moderate or large amplitude variables. With automated telescopes of modest aperature, it should be possible to obtain the type of data needed to better deduce their periods of variability. For a given star an observation or two (or perhaps more) every clear night for several years when it is observable is what is required.

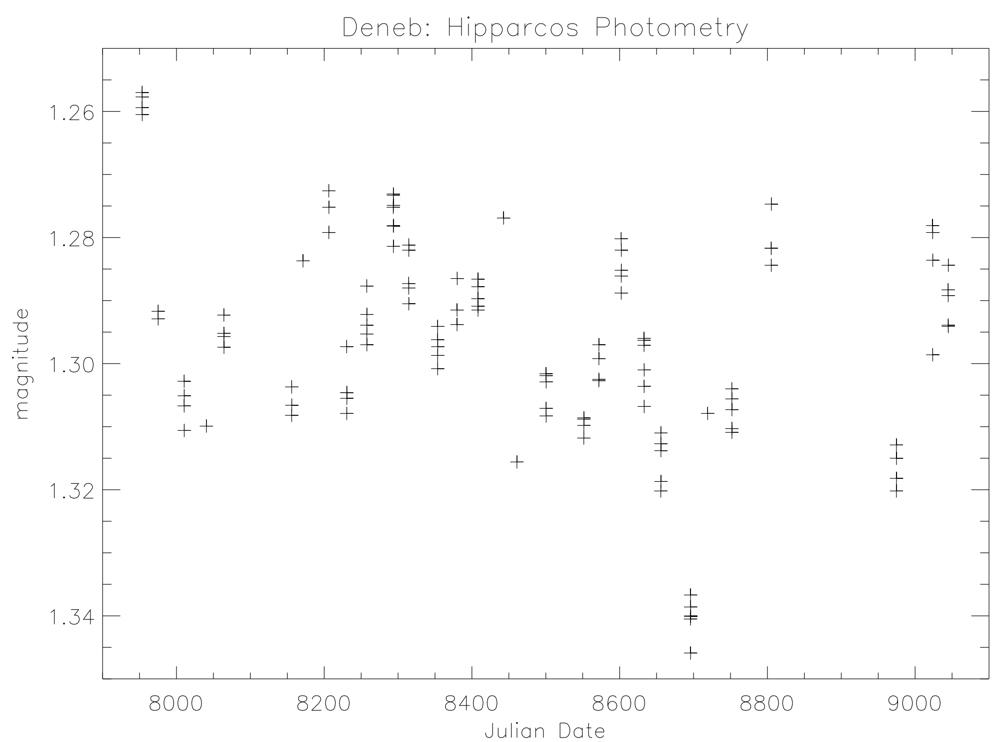

Figure 2. The Hipparcos photometry of Deneb as a function of Julian date

Table 1 also includes the periods found by the Hipparcos team for three of these stars. For HR 618 a light curve was published. But there is still a scatter of 0.03 mag. around mean curve which indicates that perhaps only one period was found. For HR 4169 no light curve is illustrated. HR 6825 is not an Ap Si star as indicated by the Hipparcos catalog. Its photometry fits its mean light curve better than that for HR 618.

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ECCENTRIC ECLIPSING BINARY STARS AS TEST OF GENERAL RELATIVITY: THE CASE OF EW ORIONIS

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The detached eclipsing binary EW Orionis (= BD +1°0976 = HD 287 727 = GSC 0104.1206 = HBV 421, $\alpha_{2000} = 5^{\rm h}20^{\rm m}9\overset{\rm s}{.}1$, $\delta_{2000} = +2°2'39\overset{''}{.}4$, $V_{max} = 9.9$ mag; Sp.: G0+G5) is a relatively well-known system having an eccentric orbit ($e = 0.08$) and an orbital period of $P_{orb} = 6.94$ days. It was discovered to be a variable star by Hoffmeister (1930), next visual observations were provided by Lause (1937), Gaposchkin (1953) and Kordylewski (1962). First photoelectric observations were obtained by Pierce (1951). Next moments of minima were determined by Busch (1976) using the photographic plates of the Sonneberg and Hartha Observatories. Radial velocities and two-colour V, R photometry of EW Ori were analyzed by Popper et al. (1986) and fundamental properties of the components were derived ($m_1 = 1.19\,{\rm M}_\odot, m_2 = 1.15\,{\rm M}_\odot, R_1 = 1.14\,{\rm R}_\odot, R_2 = 1.09\,{\rm R}_\odot$). EW Orionis is another important system for the study of the relativistic apsidal motion. The theoretically expected rotational velocity of the line of apsides caused by relativistic contribution could be $\dot\omega_{GR} = 0.0140°\ {\rm yr}^{-1}$, the classical contribution is $\dot\omega_{cl} = 0.00215°\ {\rm yr}^{-1}$.

Our photometry of EW Ori was carried out during two periods. The photoelectric measurements in standard V filter were made during January – March 1985 at the Tian-Shan Observatory of the Sternberg Astronomical Institute, Moscow, using a 50 cm reflector. The star BD +1°0923 = GSC 0104.1278 – noted also as star "*a*" by Busch (1976) – served as a comparison star. The current CCD photometry of EW Ori was carried out in March 1996 and February 1997 at the Ondřejov Observatory using a 65cm reflecting telescope with a CCD-camera (SBIG ST-6). The measurements were done using the standard Johnson V filter usually with 45 s exposure time. More details on our equipment and data reduction procedure see e.g. in Šarounová & Wolf (1997). The stars GSC 0104.1238 – listed also as star "*b*" by Busch (1976) – on the same frame as EW Ori served as the comparison star. The new times of primary and secondary minima and their errors were determined using different numerical methods and are presented in Table 1. The epochs were calculated according to linear light elements given by Busch (1976):

$$\text{Pri. Min.} = \text{HJD } 24\ 27543.350 + 6.9368515 \times \text{E}.$$

Table 1: Photoelectric times of minimum of EW Ori.

JD Hel.– 2400000+	Error [days]	Epoch	Observatory
28937.665*	0.005	201.0	Princeton
44916.8887*	0.0003	2504.5	McDonald
44947.8946*	0.0003	2509.0	McDonald
46096.15233	0.00005	2674.5	Tian-Shan
46113.2839	0.0007	2677.0	Tian-Shan
50147.2694	0.0005	3258.5	Ondřejov
50497.3691	0.0004	3309.0	Ondřejov

∗ *recalculated original data*

The apsidal motion in EW Ori was studied independently by means of an $O-C$ diagram and a light-curve analysis. For the study of the $O-C$ diagram we took into consideration all photoelectric times collected in Table 1 as well as moments published by Busch (1976). All photoelectric times of minimum were used in our computation with a weight of 10. The weight of first photoelectric measurements obtained by Pierce (1951) was reduced to 5 due to large scatter of these data. The visual and photographic times obtained by Busch (1976) were weighted with a weight of 1. A total 52 times of minimum light were incorporated in our analysis, with 37 primary eclipses among them. For the apsidal motion analysis we used a numerical method by Giménez & García-Pelayo (1983), which is a weighted least squares iterative procedure including terms in the eccentricity up to the fifth order.

Adopting the orbital inclination and eccentricity, derived from the light curve solution, of $i = 89.8°$ and $e = 0.079$ (Popper et al., 1986), the mean apsidal motion elements given in Table 2 can be determined. In this table P_s denotes the sidereal period, P_a the anomalistic period, e represents the eccentricity, $\dot{\omega}$ the rate of apsidal motion. The zero epoch is given by T_0, and the corresponding position of the periastron is ω_0. The corresponding value of the period of periastron rotation is found to be $U = 160\,000 \pm 40\,000$ yr. The $O-C$ diagram is given in Figure 1. The predictions, corresponding to the fitted parameters, are plotted as continuous and dashed lines for primary and secondary eclipses, respectively.

Residuals for the times of minimum of EW Ori with respect to the linear light elements. The continuous and dashed lines represent predictions for primary and secondary eclipses, respectively. The individual primary and secondary minima are denoted by circles and triangles, respectively. Larger symbols correspond to the photoelectric measurements with higher weight

For the light-curve analysis we used an improved iterative method of differential corrections developed for an analysis of light curves of eclipsing binaries with eccentric orbits (Khaliullina & Khaliullin 1984). Firstly we took into our calculation all photoelectric measurements and fixed the value of eccentricity at $e = 0.079$ (run I). In the second trial, the orbital period P_s was determined using all times of minima except the first photoelectric measurements of Pierce (1951) and the value of eccentricity was taken as an independent parameter (run II). Finally, in the third run, we took into consideration all photoelectric measurements for the period determination and all parameters were free

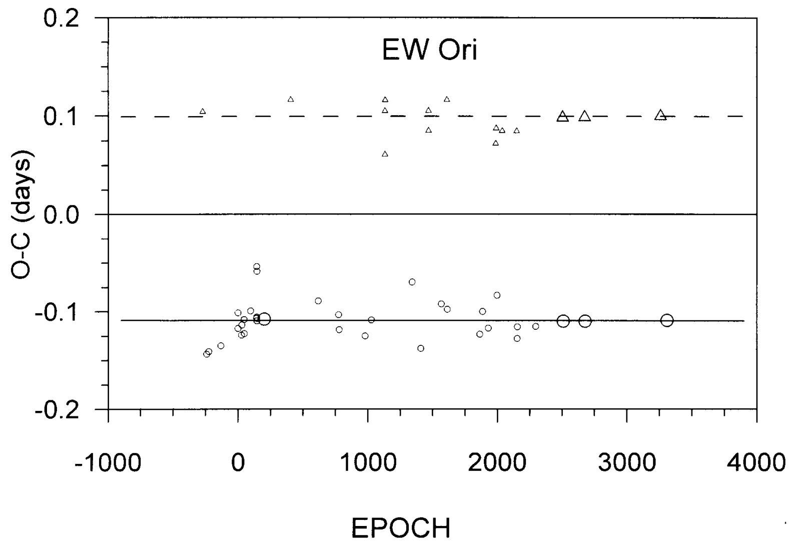

Figure 1.

during this calculation (run III). All results of this analysis are compared in Table 2.

We derived the apsidal motion elements using two independent methods on the current data set. Our results indicate that the apsidal motion rate in this system could be smaller than expected from theory. Surprisingly, the $O - C$ diagram analysis gives the rate of apsidal motion $\dot{\omega}_{obs} = 0.23°/100$ years, which is only 16 percent of the rate predicted by the General Relativity. Moreover, the second run of the light-curve analysis gives a negative value of $\dot{\omega}$. Resulting apsidal motion elements are also sensitive to the adopted weighting scheme. According to our light-curve analysis the spectral type of components should be F8 + G0.

Nevertheless, this system could be another eclipsing binary, which exhibits the discrepancy between observed and predicted rate of the apsidal motion. Another anomalous "slow" case of V541 Cygni was recently discussed by Wolf (1995) and Guinan et al. (1996) and was not yet explained satisfactorily. More high-accuracy timings of these eclipsing systems are necessary in the future to enlarge the time span for better analysis of the

Table 2: Apsidal motion parameters

	$O - C$ diagram	light-curve analysis		
		I	II	III
T_0	24 27543.4670 ± 0.0007		24 44913.2028	
P_s [days]	6.9368422 ± 0.0000012	6.9368428	6.9368446	6.9368428
P_a [days]	6.9368430 ± 0.0000012	–	–	–
e	0.079 (*fixed*)	0.079 (*fixed*)	0.067	0.063
$\dot{\omega}$ [° yr^{-1}]	0.00226 ± 0.00056	0.0097	– 0.0115	0.0189
ω_0 [°]	306.7 ± 0.4	306.9	315.3	319.1

apsidal motion.

For the present use we propose the following linear light elements for EW Ori:

$$\text{Pri. Min.} = \text{HJD } 24\ 50497.3691 + 6.936842 \times E$$
$$\text{Sec. Min.} = \text{HJD } 24\ 50147.2694 + 6.936842 \times E.$$

Acknowledgements. This work has been supported in part by the Grant Agency of the Czech Republic, grant No. 205-95-1498. We are thankful to Mr. Franz Agerer, BAV, for all timings of EW Ori taken from the Lichtenknecker's database. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France.

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ACCURATE COORDINATES FOR VARIABLE STARS

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Twenty-two new variables were reported recently by Magnan *et al.* (1997). Examination of the B1950.0 coordinates listed therein show that two of the objects are in fact listed in the *New Catalogue of Suspected Variable Stars* (Kholopov, 1982). Object 4 is NSV 13792 (Geyer and Gieseking, 1975, hereafter GG) and object 13 is NSV 13792 (Wisniewski and Coyne, 1976, hereafter WC).

Accurate coordinates for these two objects, as well as the other variable stars listed in GG and WC are given in Tables 1 and 2, respectively. The methods used in determining these coordinates has already been described (e.g., Skiff and Williams, 1997), but for convenience the sources for the positions (labeled 's' in the tables) are 'U' for positions extracted from the USNO-A1.0 catalogue and 'D' for measurements from the Digital Sky Survey using USNO-A1.0 comparison stars (Monet *et al.*, 1994; Monet *et al.*, 1996).

Table 1. *IBVS* No. 967

Name	NSV	α_{2000}	δ_{2000}	s	GSC	Note
1	NSV 13714	21 25 52.57	+62 22 32.6	U		
2	NSV 13732	21 27 40.12	+56 00 43.7	U		
3	NSV 13792	21 34 09.60	+55 35 16.3	D	3971-00499	1
4	NSV 13796	21 34 54.61	+55 56 32.3	U	3971-01155	2
5	NSV 13818	21 38 08.65	+61 31 00.7	U	4249-02167	
6	NSV 13895	21 50 17.48	+57 38 03.3	U		3
7		21 58 04.72	+60 22 33.8	U	4262-01126	
8	NSV 14007	22 02 27.68	+61 55 43.8	U		
9	NSV 14061	22 08 15.38	+61 45 24.1	U		

Table 2: *Vatican Obs. Publ.*, **1**, No. 11

Name	GCVS/NSV	α_{2000}	δ_{2000}	s	GSC	Note
VES 330	V750 Cyg	20 49 21.25	+50 31 51.2	U		4
VES 339	RZ Cyg	20 51 53.21	+47 21 20.9	U	3579-03803	
VES 340	NSV 13383	20 52 44.25	+49 52 05.5	U		
VES 341	NSV 13386	20 52 47.81	+53 02 29.9	U	3951-02189	5
VES 370	V579 Cyg	21 10 48.41	+44 10 45.8	U	3181-05031	6
VES 372	V581 Cyg	21 11 12.19	+44 32 33.9	U	3181-05019	
VES 394	V597 Cyg	21 22 01.50	+42 50 51.3	U	3190-00194	
VES 399	V604 Cyg	21 23 49.61	+42 48 05.0	U	3190-00987	

Notes:

1. Companion at end-figures $08\overset{s}{.}95/10\overset{''}{.}8$ (D).
2. $\alpha_{1950} = 20^h51^m18\overset{s}{.}79$, $\delta_{1950} = +52°51'06\overset{''}{.}2$; = object 4 of Magnan *et al.* (1997).
3. Companion at end-figures $16\overset{s}{.}89/02\overset{''}{.}8$ (U).
4. Identification confirmed by comparison with Wenzel (1953).
5. $\alpha_{1950} = 21^h32^m33\overset{s}{.}87$, $\delta_{1950} = +55°21'52\overset{''}{.}3$; = object 13 of Magnan *et al.* (1997).
6. Identification confirmed by comparison with *Astr. Abh. AN* **12**, 1/*MVS* 309.

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ERRATUM [FROM IBVS 4596]

When checking the data published in the IBVS No. 4543 issue for updating and supplementing the variable star catalogs, several incorrect and confusing statements have been found.

The last sentence of the first paragraph should read as follows:

Object 4 is NGC 13386 (Wisniewski and Coyne, 1976, hereafter WC) and object 13 is NSV 13792 (Geyer and Gieseking, 1975, hereafter GG).

In Table 1, Note 2 should be in the SAME line with Note 1 (both belong to NSV 13792).

On page 2, the contents of Note 5 and Note 2 are interchanged.

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DETERMINING THE PERIOD OF AN ECLIPSING BINARY: V1094 Tau = DHK41

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V1094 Tau = DHK41 = SAO 76494 is a ninth-magnitude star of spectral type G0 at RA $4^h9^m6^s$ DEC $+21°49'11''$ (1950). It was discovered to be an eclipsing variable by Kaiser in October 1994 from patrol photographs. A period of 3.176 day was published after several eclipses were observed visually (Kaiser 1994). Initially it was thought to be a possible member of the Hyades star cluster. Subsequent analysis suggests that if true, it would be on the outer reaches of the far side of the cluster.

Continued visual and photoelectric observations in 1995 revealed that the 3.17 day period was actually not the true period, but the interval between the secondary minimum and the following primary minimum in an eccentric orbit. Using the time of the discovery photograph, two visual and three photoelectric times of minima a new period of 4.49407 day was published (Kaiser et al., 1995).

In 1996 Larry Marshall, of Gettysburg College, informed us that his colleagues had been conducting a radial velocity study of this system and that the 4.49 day period was actually in error and that the true period is double that figure (Marshall, 1996). Doubling the period revealed that all observations to date fit both periods. The main change in the light curve was to shift the secondary eclipse from phase 0.3 to phase 0.65. The other obvious change was to widen the observational gaps in the light curve.

In January of 1997 two new times of minimum were determined by the Kwee–Van Woerden (1956) method. The first by Frey using his .51 meter telescope and SSP3 photoelectric photometer. The second by Kaiser using his .35 meter telescope and ST6 CCD. GSC 1263 606 was used as an comparison star in both cases. These data were combined with the earlier times for a least squares solution. The photoelectric/CCD data were given a weight of 10, the visual data 2, and the discovery photograph 1. The result refined the period to the sixth decimal. Table 1 lists the new O−C's. Figures 1 and 2 plot the data from Kaiser et al. phased to the new period.

$$\text{New Elements} \quad \text{Min. I} = \text{JD}\,2\,449\,701.7059 + 8\overset{d}{.}988487 \times \text{E} \qquad (1)$$
$$\pm 0.0003 \pm 0.000007$$

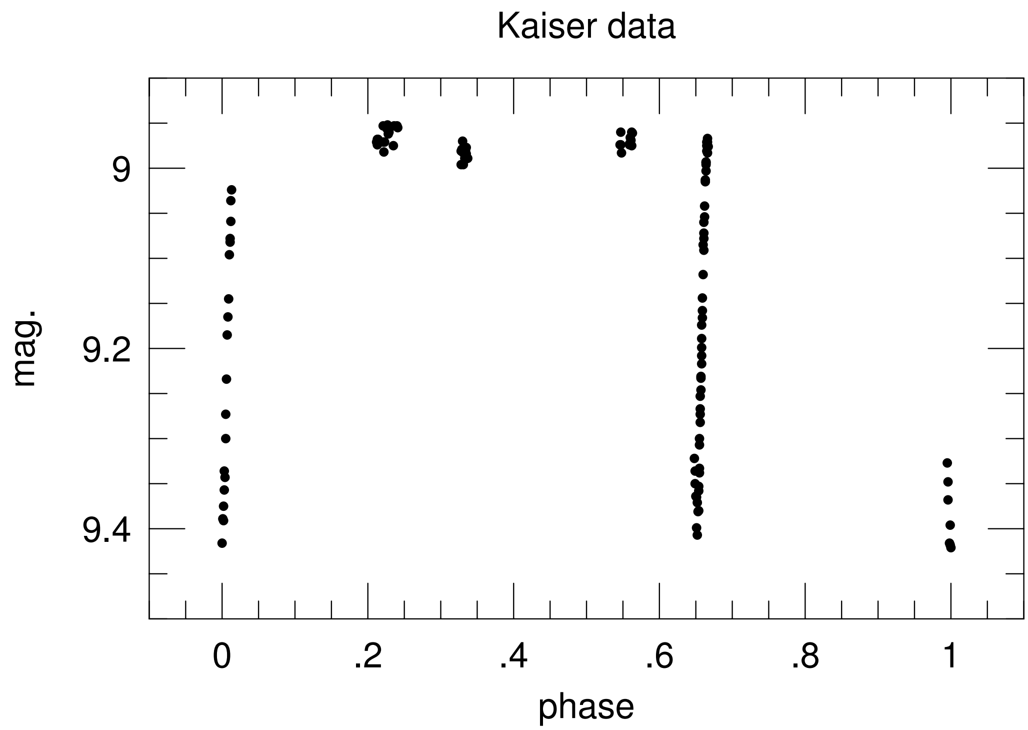

Figure 1.

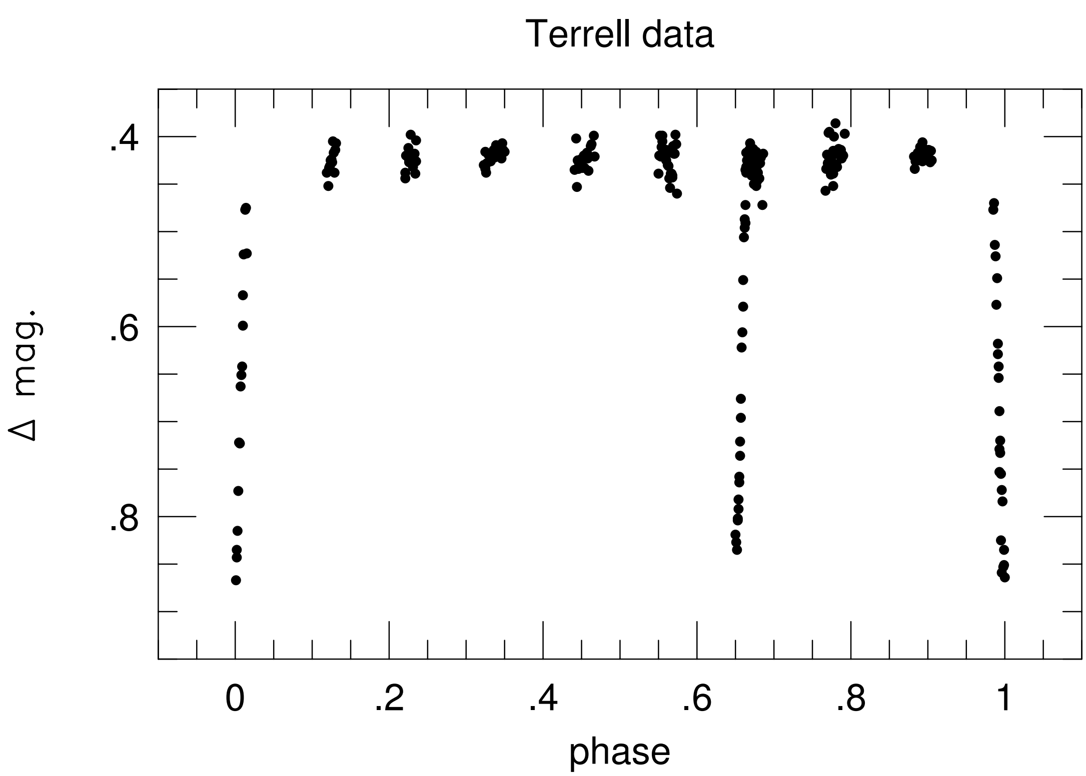

Figure 2.

Table 1: Comparison of observed minus calculated times of minima

HJD	Epoch	O−C	Observer
49602.846	−11	+0.013	Kaiser discovery ptg
49656.762	−5	0.001	Baldwin visual
49683.727	−2	−0.002	Baldwin visual
49701.7061	0	0.000	Terrell pep
49710.6950	+1	0.001	Kaiser pep
49755.6355	+6	−0.001	Kaiser pep
50456.7393	+84	0.000	Frey pep
50474.7156	+86	0.000	Kaiser CCD

Observations spanning nearly 100 cycles show that V1094 Tau is an Algol type eclipsing binary with an eccentric orbit, apparently equal eclipses with a period very close to nine days exactly. All of these factors contributed to the difficulty in determining the true period. With a spectral type of G0, it just qualifies as one of a handful of known detached late-type main-sequence eclipsing binaries.

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NEW VARIABLE STARS IN THE OPEN CLUSTER NGC 7654 (=M 52)

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We present observational results of three newly discovered slowly pulsating B stars (SPB stars; see Waelkens *et al.* 1990) and one eclipsing binary in the open cluster NGC 7654. We report also the light variation of a low amplitude δ Scuti variable star recently discovered by Viskum *et al.* (1997).

Time-series CCD photometry of the open cluster NGC 7654 was performed over five nights from October 2 to 18, 1997 at Bohyunsan Optical Astronomy Observatory (BOAO) in order to search for variable stars, particularly, SPB stars. We also carried out UBV photometry to obtain the color-magnitude diagram of the cluster. Observation log is given in Table 1. The observations were done with a TEK 1024 CCD camera attached to the BOAO 1.8m optical telescope. The field of view of CCD image is $5\farcm8 \times 5\farcm8$ at the f/8 Cassegrain focus of the telescope.

The CCD pre-processings, such as bias subtraction and flat fielding, were performed with the IRAF/CCDRED package. We applied the point-spread function (PSF) photometry to get instrumental magnitudes, using the IRAF/DAOPHOT package (Massey & Davis 1992). The standard magnitudes and colors were obtained from a typical transformation equation (e.g., Massey & Davis 1992). The ensemble normalization technique (Gilliland & Brown 1988) was applied to standardize instrumental magnitudes of all time-series CCD frames. The detailed description about data reduction and photometric results of the open cluster NGC 7654 will be given in elsewhere (Choi *et al.* 1998).

The finding chart of the five variable stars in the observed field is shown in Figure 1. Their light curves are shown in Figure 2, where the brightness of two stars, C1 and C2, are also plotted for comparison. The brightness decrease of C2 near HJD 2450738.2 may be caused by the contamination of a nearby bright star (V1) under poor seeing condition. As seen in the figure, it is evident that V1, V2 and V3 show long-term (night to night) light variations. The brightness of V4 increases steeply by about $0\overset{m}{.}3$ near HJD 2450724.17 and remains constant at another time. The light curve of V4 is similar to that of an Algol-type eclipsing binary. We also detected slight light variations of V5, which was recently identified as a δ Scuti star candidate by Viskum *et al.* (1997).

Using the Fourier analysis and phase-match technique, we obtained pulsation periods of three newly discovered variable stars. The main results for the five variable stars are summarized in Table 2. The resulting period of V5 ($\simeq 0\overset{d}{.}278$) is in good agreement with the result of Viskum *et al.* (1997). The phase diagrams of four variable stars are shown in Figure 3.

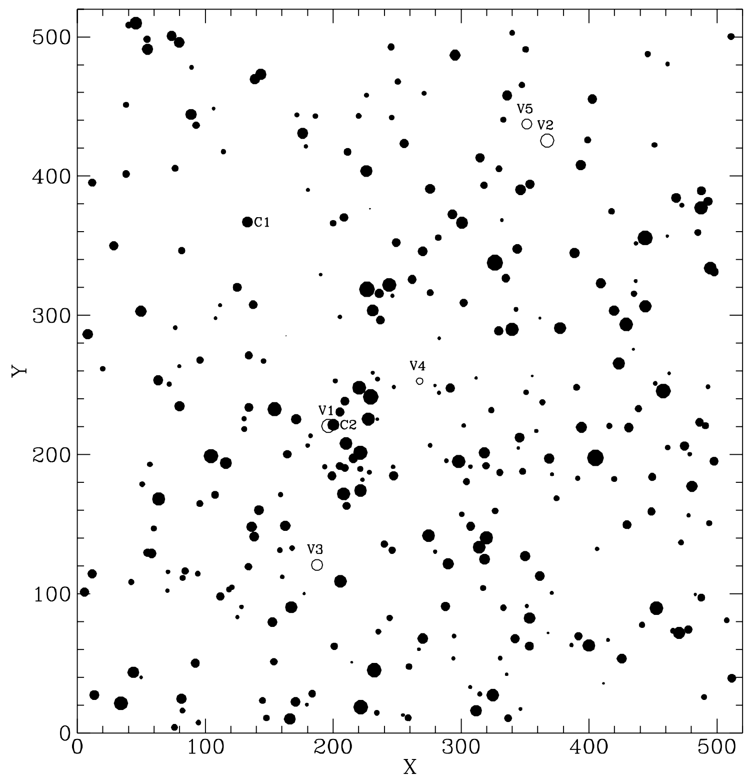

Figure 1. Observation field (5.'8 × 5.'8, 0."68/pixel) of the open cluster NGC 7654. Five variable stars (V1, V2, V3, V4 and V5) are denoted as open circles

Table 1. Observation Log

Date	Start HJD	Coverage	$N_{obs.}$	Filter	Seeing	Remark
Oct. 2	2450724.16	$4^{h}.8$	116	B	1."2	clear
3	725.16	$4^{h}.5$	127	B	1."5	clear
16	738.05	$6^{h}.9$	314	B	1."8	cirrus
17	739.03	$3^{h}.8$	209	B	1."7	cirrus
18	740.08	$6^{h}.8$	449	UBV	1."3	clear

In Figure 4, we show the location of five variable stars on the C−M diagram of the cluster. Their absolute magnitudes and intrinsic colors were calculated from distance modulus of $(V - M_{\rm v})_{\rm o}=10^{\rm m}.9\pm0^{\rm m}.2$ and interstellar reddening of $E(B-V)=0^{\rm m}.62\pm0^{\rm m}.05$ (Choi *et al.* 1998). We adopted a theoretical isochrone of log(age)=8.0 for solar metal abundance (Bertelli *et al.* 1994). Three variable stars of V1, V2 and V3 are identified as late-B type main-sequence stars located at the SPB stars instability strip (Dziembowski *et al.* 1993). The δ Scuti star V5 is located at the blue edge of δ Scuti stars instability strip (Breger 1979).

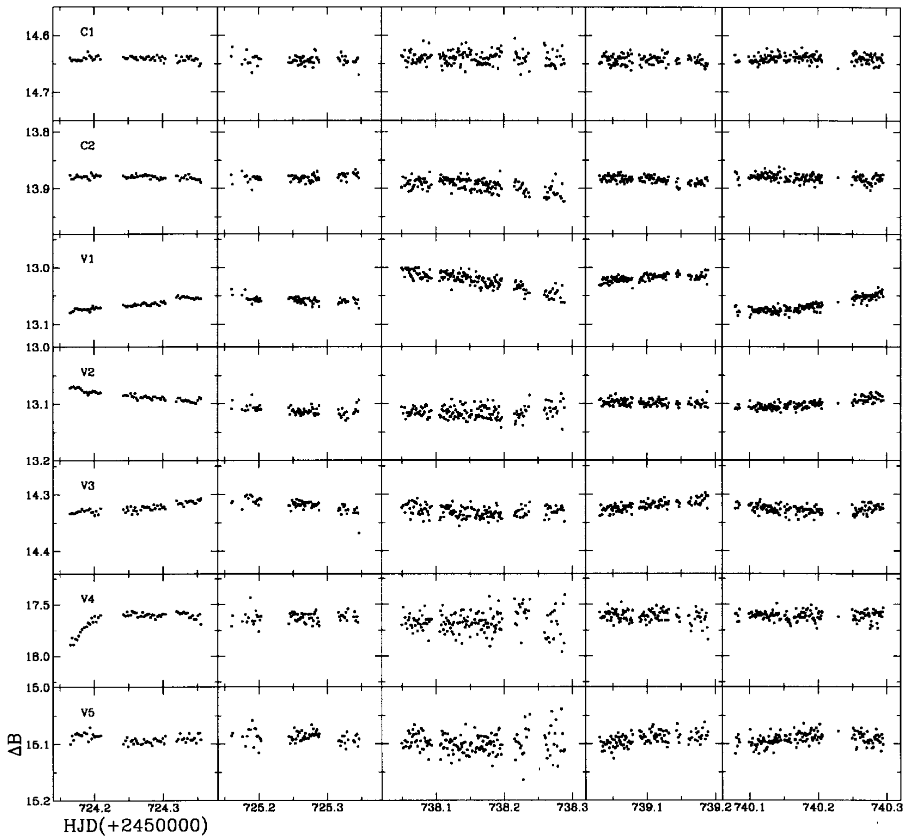

Figure 2. Light variations of five variable stars. The brightness of two stars, C1 and C2, are also plotted for comparison

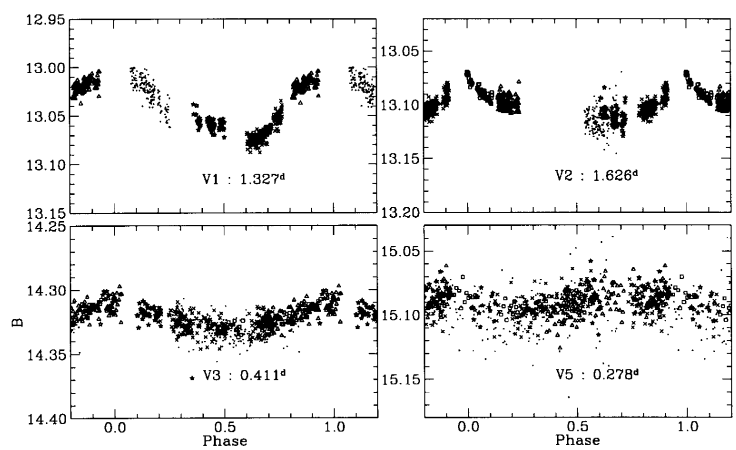

Figure 3. Phase diagrams of four variable stars. Data points are differently marked for each observation night

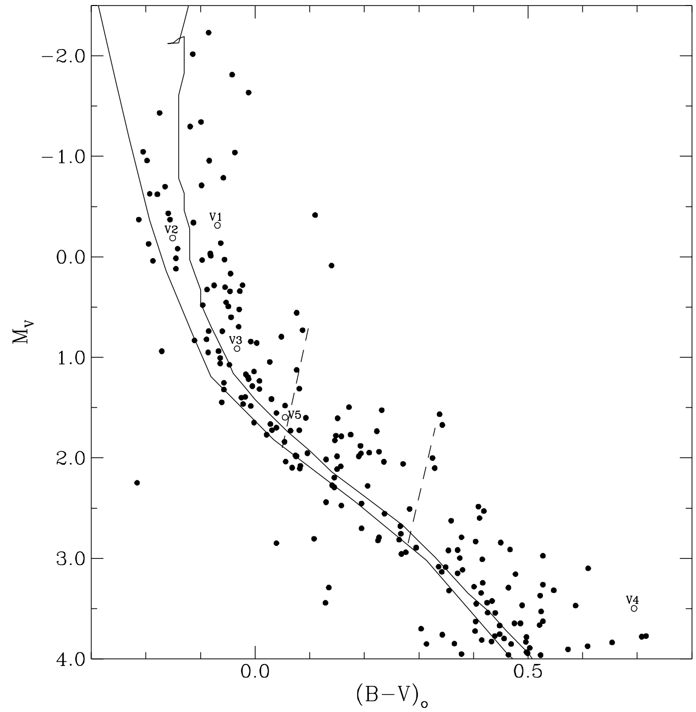

Figure 4. Five variable stars on the C−M diagram of NGC 7654 (see text in detail). The upper solid line is a theoretical isochrone of log(age)=8.0 (Bertelli *et al.* 1994) and the lower is the ZAMS (Lee & Sung 1995) for solar metal abundance. The dashed lines are the borders of δ Scuti stars instability strip given by Breger (1979). The five variable stars are denoted as open circles

Table 2. Main observational results of five variable stars in the open cluster NGC 7654

ID	RA(2000)	DEC(2000)	V	B−V	Period	ΔB	Max. epoch	Type
V1*	$23^h24^m52\overset{s}{.}2$	$61\overset{\circ}{.}36'30''$	$12\overset{m}{.}51$	$0\overset{m}{.}55$	$1\overset{h}{.}327$	$\sim 0\overset{m}{.}07$	2450737.95	SPB
V2*	$23^h24^m35\overset{s}{.}9$	$61\overset{\circ}{.}38'49''$	$12\overset{m}{.}64$	$0\overset{m}{.}47$	$1\overset{h}{.}626$	$\sim 0\overset{m}{.}05$	2450724.16	SPB
V3*	$23^h24^m53\overset{s}{.}1$	$61\overset{\circ}{.}35'22''$	$13\overset{m}{.}74$	$0\overset{m}{.}59$	$0\overset{h}{.}411$	$\sim 0\overset{m}{.}02$	2450724.38	SPB
V4*	$23^h24^m45\overset{s}{.}4$	$61\overset{\circ}{.}36'52''$	$16\overset{m}{.}32$	$1\overset{m}{.}31$		$\sim 0\overset{m}{.}3$		EA
V5**	$23\overset{h}{.}24^m37\overset{s}{.}4$	$61\overset{\circ}{.}38'57''$	$14\overset{m}{.}42$	$0\overset{m}{.}68$	$0\overset{h}{.}278$	$\leq 0\overset{m}{.}02$	2450740.23	δ Scuti

* : discovered in this study, ** : discovered by Viskum *et al.* (1997).

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NSV 03199: AN ECLIPSING BINARY SYSTEM IN AURIGA

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Among the many detected variables recorded in the NSV catalogue (Kholopov, 1982), NSV 03199 (= HV 7661 = GSC 3394.1630 = CSV000851) was included as an RR Lyrae object with a photographic magnitude range between $13^{m}_{.}3$ and $13^{m}_{.}8$, after Shapley and Boyd (1937).

Due to the lack of additional light measurements, NSV 03199 was included in a collaborative observing program between the US Naval Observatory Flagstaff Station and Esteve Duran Observatory. The star was monitored in the BVRI bands with the 1.0-m Ritchey-Chretien telescope at the USNO Flagstaff Station, and in the V band with the 0.6-m telescope at Esteve Duran Observatory, between September 1996 and November 1997. Some stars in the field of NSV 03199 were placed on the standard system by using Landolt (1992) standards, and GSC 3394.1226 was used as the primary comparison star.

Figure 1 shows the field of NSV 03199, and Table 1 lists the standard V magnitudes and color indices of comparison stars near the variable.

Table 1

Star	GSC	V	B−V	V−R	R−I
A	3394-1226	12.987±0.005	0.632±0.003	0.378±0.004	0.365±0.005
B	3394-1430	14.839±0.017	0.736±0.002	0.404±0.018	0.417±0.012
C	3394-1468	10.880±0.020	1.444±0.017	0.803±0.006	0.673±0.013
D	3394-1696	13.695±0.004	0.658±0.002	0.395±0.008	0.389±0.008
E	3394-1783	10.708±0.005	1.785±0.000	0.866±0.000	0.465±0.005
F	3394-1845	14.685±0.002	0.653±0.003	0.389±0.006	0.368±0.027
G	3394-1875	12.632±0.003	1.182±0.004	0.632±0.003	0.596±0.005
H	3394-2071	15.063±0.005	1.041±0.010	0.598±0.006	0.549±0.017
I	3394-2075	13.845±0.003	0.591±0.003	0.360±0.002	0.381±0.009
J	3394-2200	11.574±0.003	1.300±0.002	0.720±0.002	0.630±0.005
K	3394-2249	12.145±0.005	0.850±0.004	0.491±0.000	0.411±0.006
L	3394-2292	15.022±0.005	0.607±0.009	0.385±0.010	0.392±0.035
M	3394-2448	13.374±0.004	0.583±0.002	0.356±0.002	0.370±0.006

Photometric observations show that NSV 03199 is an eclipsing binary system and not an RR Lyrae star (Figure 2), with a period close to one day. At maximum light this object has a V magnitude of 12.72, and an average (B−V) color index of $0^m_.340 \pm 0^m_.010$, fading 0.53 magnitudes at primary minimum and $0^m_.10$ at minimum II. Photometric data also suggest that the B−V color remains almost unchanged at minimum I. The following ephemeris was derived:

$$\text{Min. I} = \text{HJD } 2450510.46542 + 1^d_.04640 \times E$$
$$\pm 0.00060 \pm 0.00013$$

Table 2 lists the two observed primary minima and their O−C residuals:

Table 2

HJD	Epoch	O−C
2450510.46542	0.0	0.0000
2450511.51370	1.0	+0.0019

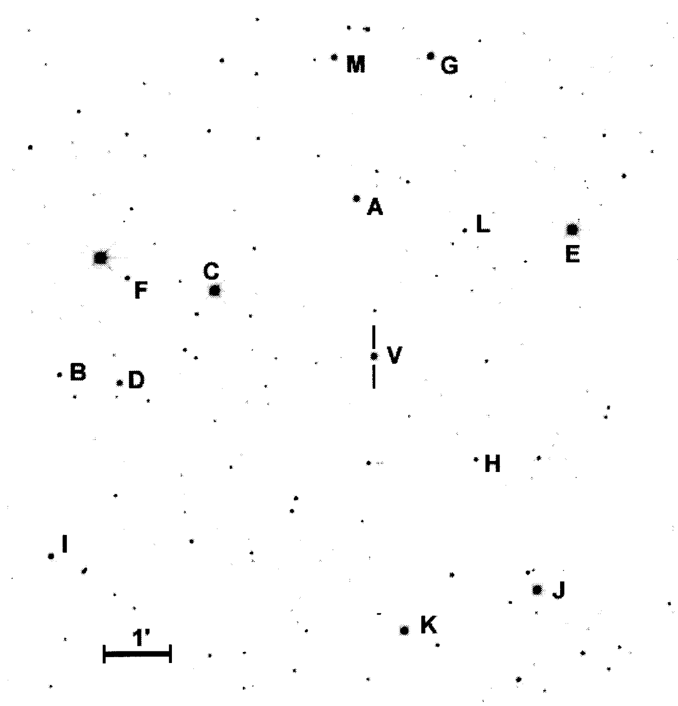

Figure 1. Finding chart for the variable. V = NSV 03199. North is on top

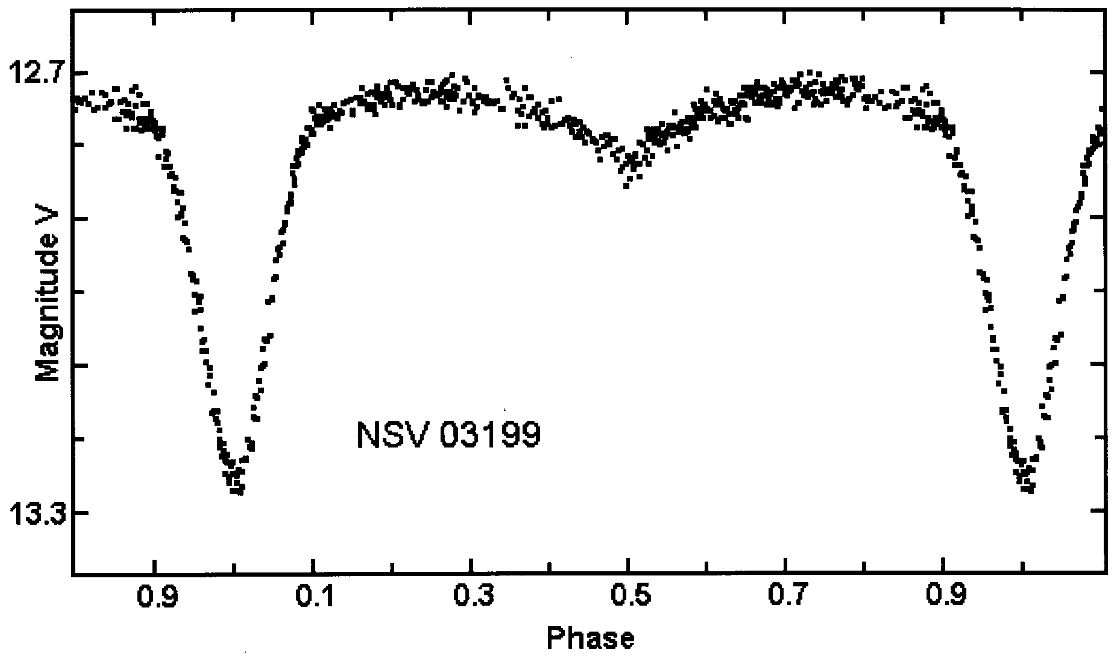

Figure 2. Light curve of the variable phased according to the given ephemeris

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A MODEL FOR V4 IN THE GLOBULAR CLUSTER M3

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The images used in this study were obtained with the No. 1 0.9-meter telescope at the Kitt Peak National Observatory using "Harris" B and V filters. The field was first observed for six nights during May 1992 and again for seven nights in April 1993. Follow-up observations were made in 1995 and 1997. The data presented here are the 83 B frames from 1992 and the 100 B frames from 1993. The raw data frames were processed and reduced following standard procedures using ALLSTAR in DAOPHOTX in IRAF. Twenty-three Landolt standards were observed during the 1993 run and used to place the stars on the standard system. The 1993 V data has been reduced and used to determine color.

V4 has been recognized as a possible blend of variable stars (Goranskij, 1994) and in this paper we are able to account for the color of V4 and the shape of its light curve with a superposition of three stars: a single nonvariable star and two RRab variables of differing amplitude and phase but with very nearly the same period.

There are almost certainly two variable stars in the light curve of V4. The period, the amplitudes, and the shape of the light curves all suggest RRab variables. The intensity averaged magnitude for V4 is approximately one magnitude brighter than the horizontal branch (and specifically, greater than 0.75 mag), and the color of V4 is well to the red of the instability strip. Thus, it does not seem likely that V4 is simply a combination of two variable stars.

We have been able to model the color and light curves of V4 with a superposition of three stars: a nonvariable star and two RRab variables. The magnitude averaged B magnitude of V4 is 15.047 and its magnitude averaged V magnitude is 14.538 for a color of 0.509, well to the red of the instability strip. The two RRab variables in our model have an intensity averaged B magnitude of 15.999. The intensity averaged B magnitude of V4 is 15.015. Thus, the nonvariable in the model has B = 16.786. Using a typical value for the color of an RRab variable, the color of the nonvariable is approximately 1.0. Unfortunately, a star with these properties would be well to the red of the red giant branch of M3 and thus unlikely to be a member of the cluster. The B amplitudes of the two RRab stars in the model are 1.73 and 1.00 respectively. In our model we have used the same period for stars 1 and 2 (0.5868 day) because this period seems to phase the data reasonably well and to try to model V4 using two different periods would have been very difficult. The shift in phase between the primary and secondary maxima from 1992 to 1993 shows that the periods are not exactly the same. Light curves for V4, star 1, star 2, and the three-star model are given in Figures 1 and 2. In these Figures, the squares represent the light curve of V4 and X represents the light curve of the three-star model.

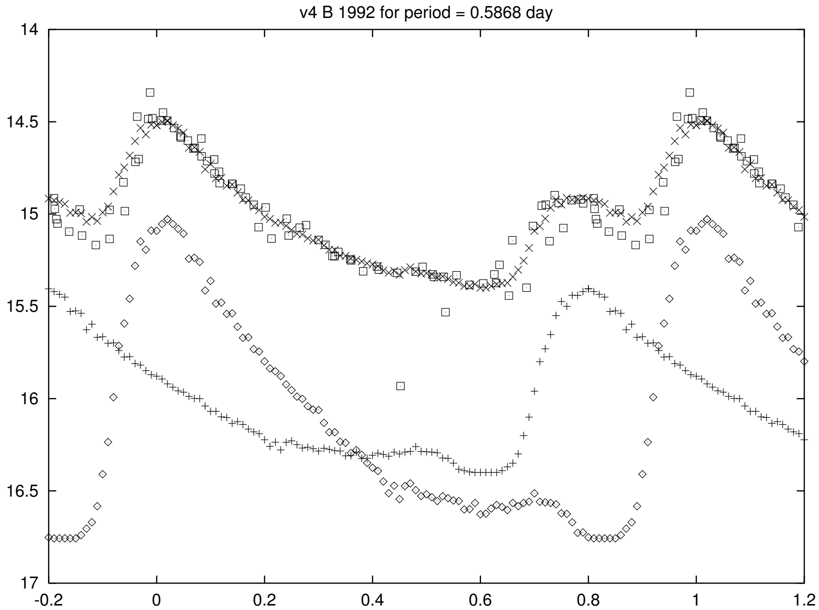

Figure 1.

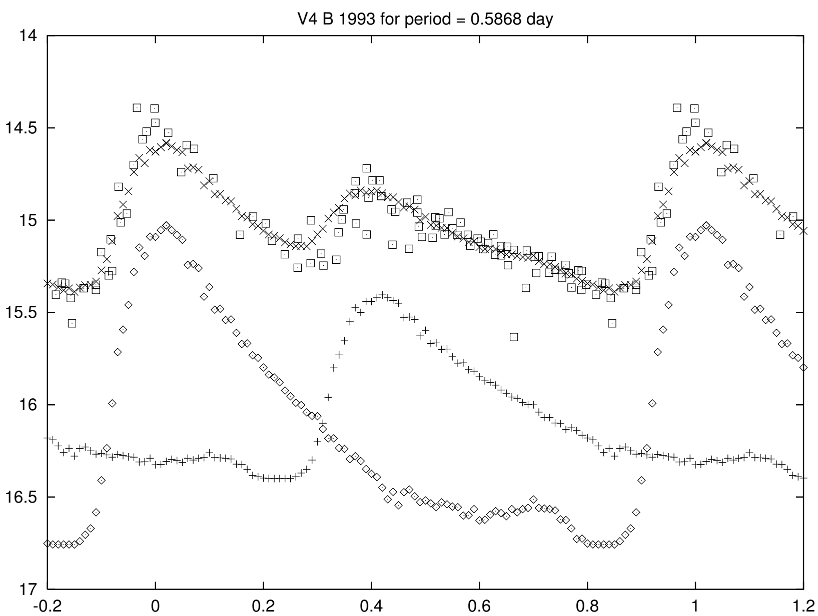

Figure 2.

Reference:
Goranskij, V.P., 1994, *IBVS*, No. 4129

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THE DISCOVERY OF TWO NEW DOUBLE-MODE RR LYRAE (RRd) VARIABLES IN THE GLOBULAR CLUSTER M3

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The images used in this study were obtained with the No. 1 0.9-meter telescope at the Kitt Peak National Observatory using "Harris" B and V filters. The field was observed for six nights during May 1992 and again for seven nights in April 1993. The data reported here are the 83 B frames from 1992 and the 100 B frames from 1993. The raw data frames were processed and reduced following standard procedures using ALLSTAR in DAOPHOTX in IRAF.

In the globular cluster M3, V68 and V87 have been known as RRd variables since 1982, V79 was recently discovered as an RRd (Clement et al. 1997), and we identify V99 and V166 as RRd variables in this paper. We determined the primary periods for the RRd variables with a computer program that utilized Stellingwerf's (1978) phase dispersion minimization (PDM) technique with a (5,2) bin structure. To search for the secondary period, we derived a mean light curve by fitting a cubic spline interpolating function to the bin means, then measured the residuals from this curve and applied the PDM technique to the residuals to determine the secondary period. Next, we corrected the magnitudes by subtracting the mean curve for the secondary period from the raw magnitudes and then, again applied the PDM technique to obtain a final value for the primary period.

This was done for both the combined 1992-1993 data and again for each year separately. There appears to be year-to-year changes (and in some cases, very significant changes) in the properties of the RRd variables in M3. V166 is the most striking in this regard.

For V166 the dominant pulsation mode in 1992 was the fundamental mode with a period of 0.4829 day and an amplitude of 0.75 mag. The 1992 data show a secondary pulsation in the first overtone with a period of 0.3593 day and an amplitude of 0.31 mag. In 1993, just 11 months later, the dominant mode is the first overtone with a period of 0.3566 day and an amplitude that has increased from 0.31 mag to 0.34 mag. The secondary pulsation is the fundamental with a period of 0.4815 day and an amplitude that has decreased from 0.75 mag to 0.23 mag. If the mode shift is an evolutionary effect, this would be additional evidence for blueward evolution for M3 as suggested by Clement et al. (1997) and others.

For V99 the amplitude of the primary, first-overtone oscillation, relative to the secondary, fundamental, increased significantly from 1992 to 1993, again indicating blueward evolution. There seems to have been a similar increase for V68 and V79 but that is not as clear. In both cases the amplitude of the primary appears to have decreased but the amplitude of the secondary decreased even more. V87 appears to have decreased the amplitude of the primary, first- overtone oscillation relative to the secondary, fundamental, though for both 1992 and 1993, the amplitude of the secondary is very small and difficult to estimate accurately. The properties for the RRd variables in M3 are shown in Table 1.

Table 1. Properties for the RRd Stars in M3

Star	P_1	P_0	A_1/A_0 1992	A_1/A_0 1993	$A_1/A_0{}^\star$ 1996	$A_1/A_0{}^\star$ 1920-6
V68	0.356	0.479	1.19	1.62	1.12	0.72
V79	0.358	0.480	1.28	1.48	1.73	<0.2
V87	0.357	0.480	3.05	2.34		
V99	0.361	0.485	1.93	3.23		
V166	0.358	0.482	0.41	1.46		

* from Clement et al. (1997)

References:

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Stellingwerf, R., 1978, *ApJ*, **224**, 953

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THE NATURE OF V829 Aql – A TRIPLE-MODE RADIALLY PULSATING POST-MAIN-SEQUENCE DELTA SCUTI STAR

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Diethelm (1997, hereafter D97) obtained time-resolved CCD photometry of V829 Aql during 25 nights in 1995 and 1997 (see his paper for more information). He suggested that this star is a multimode radial pulsator.

These observations have been analysed with respect to the underlying pulsational frequencies. Starting with his 1997 measurements (which are of better quality and more numerous than the 1995 data), we computed amplitude spectra and performed multifrequency sine-wave fits using the program package Period 98 (Sperl 1998). Our resulting amplitude spectra before and after successive prewhitening of simultaneously optimized frequencies are shown in Figure 1.

From Figure 1 it can be seen clearly that (at least) four frequencies are present in the light variations of V829 Aql. Furthermore, some harmonics of these frequencies ($2f_1$, $2f_2$, $3f_2$) can be discerned after prewhitening the four dominant peaks. Because of the small amount of data we did not attempt to fit these frequencies to push the analysis further.

With that knowledge, we attempted a frequency analysis of the 1995 measurements. The frequencies f_1, f_2 and f_3 are present in these data as well, but because of severe aliasing and the higher noise level, they do not dominate the amplitude spectra. After prewhitening these three frequencies, the first harmonics of them can be seen as well ($2f_1$, $2f_2$, $2f_3$). Again, we did not try to calculate a higher order fit at this point.

The results of our frequency analysis are summarized in Table 1. The error bars have been determined following Kovács (1981) and should be taken only as formal values; the real errors may be higher by up to a factor of 2.

Table 1. Frequencies detected in the light curves of V829 Aql

Ident.	Freq. (1995) (cycles/day)	Ampl. (1995) (mmag)	Freq. (1997) (cycles/day)	Ampl. (1997) (mmag)
f_1	4.529 ± 0.006	83 ± 20	4.5260 ± 0.0008	85 ± 4
f_2	3.415 ± 0.006	75 ± 20	3.4196 ± 0.0008	82 ± 4
f_3	5.664 ± 0.006	64 ± 21	5.6597 ± 0.0025	29 ± 4
$f_4=f_1+f_2$	–	–	7.9498 ± 0.0022	26 ± 4

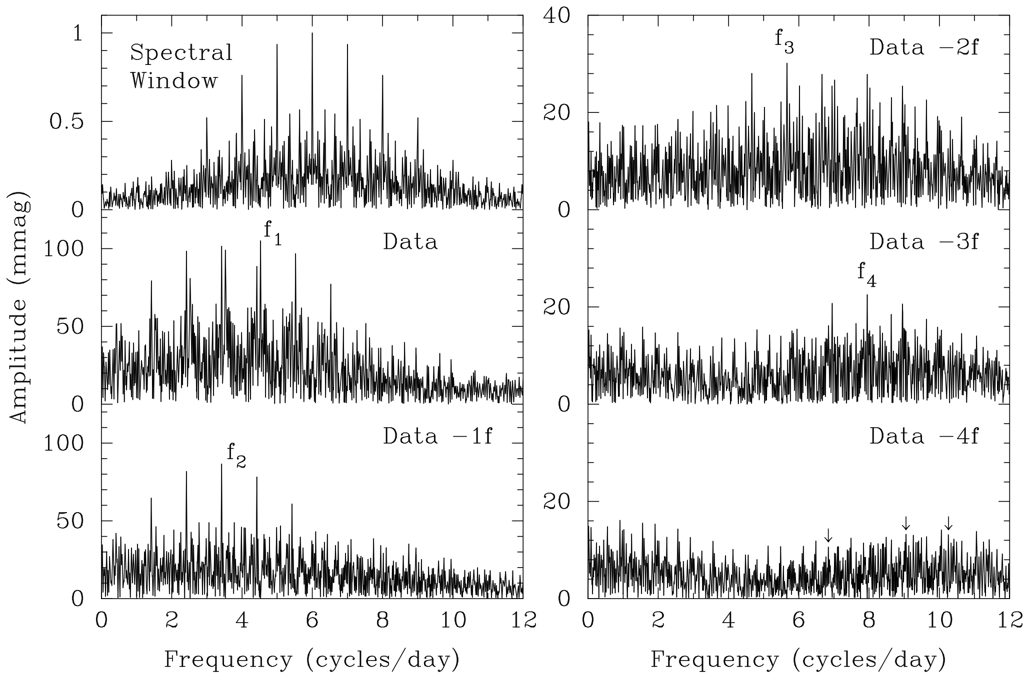

Figure 1. Amplitude spectra for the 1997 measurements of D97. Four frequencies can be identified and some further linear combinations of them (indicated with arrows) may be present

From Table 1 it may be suspected that the amplitude of f_3 was different between the two seasons, which is supported by the presence of its first harmonic in the 1995 data. However, keeping the error sizes in mind, this statement is only preliminary. Because of the significantly different quality of the two yearly subsets of data and because of the large gap between them, we did not attempt to calculate multifrequency fits for the whole data set. We rather base the following discussion on the 1997 data only.

What is the cause of variability of V829 Aql? The frequency ratios $f_2/f_1=0.7555\pm0.0002$ and $f_1/f_3=0.7997\pm0.0004$ together with the presence of linear combinations and harmonic frequencies strongly point towards the excitation of radial pulsations in the fundamental mode (F) plus the first and second overtones (1H and 2H, respectively).

In a first approach to unravel the nature of V829 Aql, we can state that it is either an RR Lyrae star or an evolved δ Scuti star. Unfortunately, we have no spectroscopic information on this object. Garcia-Melendo & Clement (1997) compiled the periods for field and cluster double-mode RR Lyrae (RRd) stars. The radial fundamental mode periods for these stars are between 0.46–0.58 days, much longer than the 0.292 days we determined for V829 Aql. The F/1H frequency ratios for RRd variables are confined to a narrow range between 0.742 and 0.747, smaller than the value we derived for V829 Aql. Moreover, if we determine the location of the star in the $(P_1/P_0 - P_2/P_0)$ vs. P_0 diagram of Kovács & Buchler (1994, hereafter KB94), we see that it cannot be represented with any of their RR Lyrae star models. All this, together with the low galactic latitude ($b = -10\overset{d}{.}7$) of the star, strongly suggests that V829 Aql is not an unusual RRd variable, but rather an evolved δ Scuti star.

To verify this suspicion, we computed a number of post-main-sequence δ Scuti star model sequences with the Warsaw-New Jersey stellar evolution and pulsation code (see Pamyatnykh et al. 1998 for more details). Since we do not have any information on the metallicity of the star, we assumed solar abundances.

We followed the work by KB94 and evaluated the behaviour of their parameter Δ, the "period ratio distance", which is a measure of the deviation of the theoretical 1H/F and 2H/F period ratios from the corresponding observed period ratios. The "best" models are then characterized by a minimum of Δ at the radial fundamental mode period. This was done along several evolutionary tracks for different masses, and the results of this investigation are displayed in Figure 2.

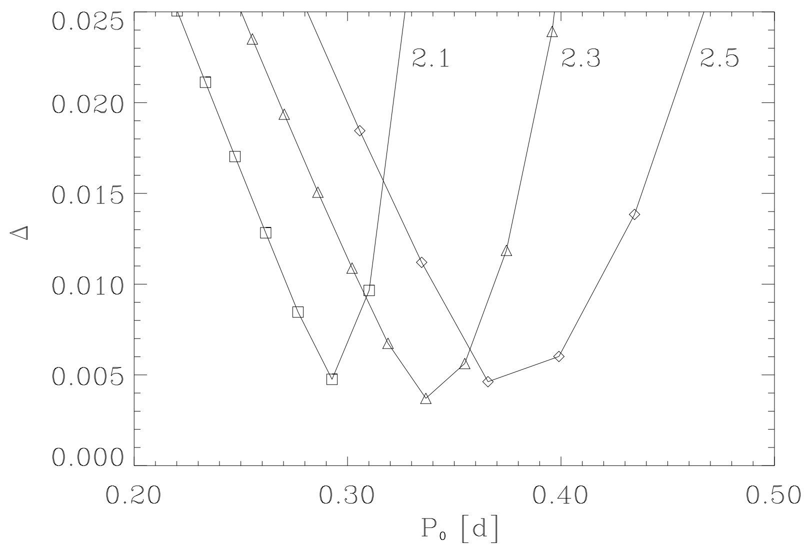

Figure 2. The period ratio distance Δ vs. the radial fundamental mode period along post main sequence evolutionary tracks of 2.1 $M_\odot$ (squares), 2.3 $M_\odot$ (triangles) and 2.5 $M_\odot$ (diamonds). The 2.1 $M_\odot$ model resembles the observed quantities for V829 Aql very well

As one can see, the 2.1 $M_\odot$ model is an excellent match to the observed quantities. Intriguingly, this model has the radial fundamental mode at a frequency of 3.4162 cycles/day, while this mode has a frequency of 3.4196 cycles/day in the real star. However, we are unable to reach $\Delta = 0$, and this best model is slightly outside the red edge of the instability strip. Both problems may be resolved by varying the metallicity of the models. From the work of KB94 and from this example it is clear that stars like V829 Aql can considerably contribute to the evaluation of the reliability of pulsational model calculations: if a sufficient amount of information on these stars is available to constrain their position in the HR diagram (i.e. $T_{\rm eff}$, $\log g$, $[M/H]$), the models must be able to reproduce their pulsational behaviour. This will also have impact on the model calculations presently used for asteroseismology of multimode nonradial δ Scuti pulsators.

At this date, only two (or three) δ Scuti stars simultaneously pulsating in the radial fundamental as well as the first and second radial overtone modes are known besides V829 Aql. These are AC And (Fitch & Szeidl 1976, KB94), GSC 4018.1807 (Antipin 1997) and perhaps HR 6434 (Scheck 1990 and references therein).

Regrettably, at best only low-resolution spectroscopy is available for AC And, GSC 4018.1807 and V829 Aql and only single-color broad-band photometric observations have been analysed in the literature. While the faintness of the three stars ($V > 10$ mag) requires a fairly large telescope to obtain high-resolution spectra, multicolor narrow and/or broad-band photometry can be obtained by photometrists with a large amount of available telescope time, an APT or well-equipped amateur astronomers.

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HD 17892, A NEW DELTA SCUTI STAR

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We are currently undertaking a large multisite campaign for the main-sequence δ Scuti star XX Pyx (Handler & Breger 1997). Since this star is not available all night from Northern Hemisphere observatories, we selected a backup program for the rest of the nights. We decided to undertake a search for rapidly oscillating Ap (roAp) stars in the Northern Hemisphere. Our candidates were carefully selected from Strömgren and Geneva photometry as well as spectral classification.

The observations were carried out with a two-channel photometer attached to the 0.9m telescope at McDonald Observatory, Fort Davis, Texas. We acquired continuous 10-second integrations through a Johnson B filter in both channels, only interrupted by sky background measurements.

As our first target, we chose BD+39°654. It has been classified as SrCrEu by Bidelman (1983). Schneider's (1986) Strömgren photometry yields $(b-y)_0 = 0.136$, $\delta m_1 = -0.095$ and $\delta m_1 = -0.267$, while Geneva photometry (Burki et al. 1998) results in $[\Delta] = 0.163$ and $[g] = 0.162$. All these features are typical for roAp stars.

We tested BD+39°654 for rapid light variations in the night of January 16/17, 1998. We chose HD 17892 as our channel 2 comparison star. While our roAp candidate did not show indications of variability, we noticed light variations of the comparison star and continued the observations. The reduced light curve of HD 17892, where the integrations have been summed into 2-minute bins, is shown in Figure 1 together with an amplitude spectrum for both stars.

A frequency analysis of this run yields a period of 71.2 ± 1.3 minutes with a B amplitude of 4.1 ± 0.4 mmag. The error bars have been determined following Kovács (1981) and should be taken only as formal values; the real errors may be higher by up to a factor of 2. From an inspection of Figure 1 it can be suspected that the light curve of HD 17892 is multiperiodic, but our data set is to small to prove this.

The HD spectral type of HD 17892 is A5. From this and from the period and amplitude we derived for the star we conclude that it is a δ Scuti pulsator. Mode stability considerations allow us to estimate that this object is near the middle of its main sequence evolution. Strömgren photometry would allow to support this conclusion, but no optical photometric indices of HD 17892 have been determined up to now.

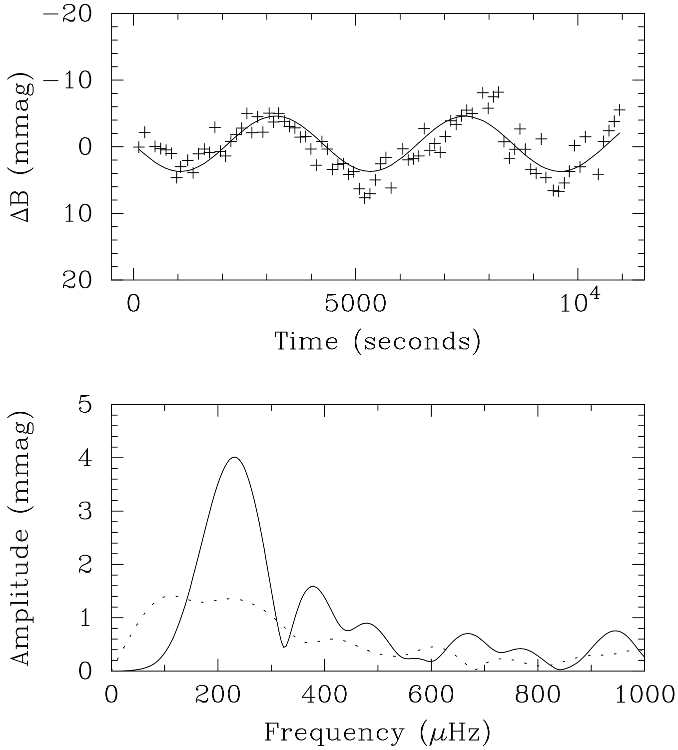

Figure 1. Upper panel: reduced light curve of HD 17892 together with a single-frequency fit (see text). Lower panel: amplitude spectrum of this run for HD 17892 (full line) and BD+39°654 (dashed line)

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STRÖMGREN PHOTOMETRY OF THE T TAURI STAR SU AURIGAE: ECLIPSE-LIKE VARIABILITY AND AGE DETERMINATION

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SU Aurigae (HD 282624; G2 IIIe; $\langle V\rangle = +9.23$ mag; $\langle B-V\rangle = +0.83$) is one of the brightest archetypical classical T Tauri stars (CTTS). CTT stars are pre-main sequence stars with accretion disks. They have spectral types of typically F to K, exhibit weak Hα and Ca II emissions, have broad absorption lines (implying rapid rotation), and are located well above the main-sequence. From an analysis of the variability of its Hα line profiles, Giampapa *et al.* (1993) found a possible ~3.0 day periodicity which is attributed to the rotation period of the star. Also, Hartmann *et al.* (1986) report a projected rotational velocity of $v\ sin\ i = 66.2 \pm 4.6$ km/s, which indicates rapid rotation.

The recently determined distance from Hipparcos (ESA, 1997) of $r = 151 \pm 40$ pc confirms that SU Aur is member of the Taurus-Auriga star-forming complex. Furthermore, AB Aur (HD 31293; A0pe; $V = +7.06$; $B-V = +0.13$), is a nearby bright companion to SU Aur. The two stars are separated by 3.5 arcmin and AB Aur is itself classified as an early-type T Tau star. Since AB Aur has a nearly identical parallax ($r = 144 \pm 20$ pc) and similar proper motions to its fainter companion, it appears that SU Aur and AB Aur are physically linked – perhaps a common proper motion pair, or are members of the same local star forming region. If we assume that they are at the same distance, then the two stars are separated by about 31,500 AU.

Although SU Aur is one of the brightest CTT stars, only a few concentrated photometric studies have been devoted to this interesting young star. Herbst *et al.* (1994) have published a catalogue of *UBVRI* photometry of T Tauri stars which includes SU Aur (as well as AB Aur). They classify SU Aur and AB Aur as early-type T Tauri stars (ETTS). They report a range of V-mag of +8.93 to +9.77 for SU Aur from photometry extending from JD 2439095 to JD 2447605. The light variations of SU Aur do not appear to be periodic. Also the light variations appear not to be accompanied by spectral changes (*i.e.* veiling effects).

Photoelectric photometry of SU Aur was made using the 0.8m Automatic Photoelectric Telescope (APT), located at Fairborn Observatory, Mt. Hopkins, Arizona. The photometry was made using intermediate-band filters very closely matched to the Strömgren *uvby* system. The observations reported here were made from November 1993 to March 1994. The photometry was made differentially with respect to the nearby comparison

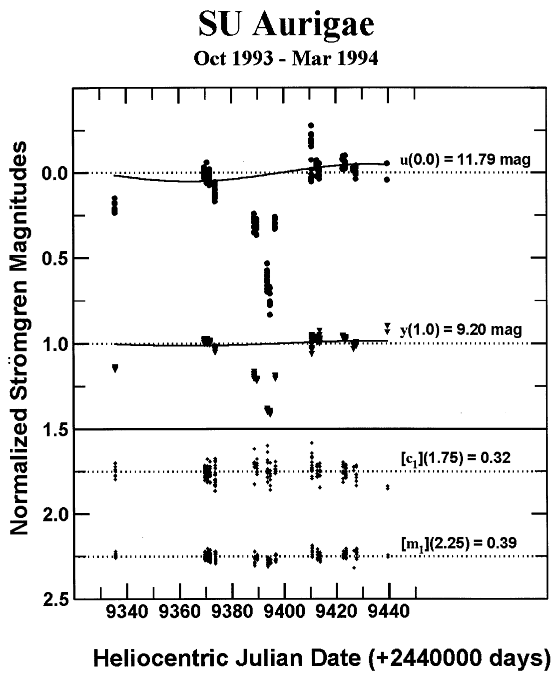

Figure 1. u and y light curves for SU Aur are shown in the top panel with the Strömgren $[c_1]$ and $[m_1]$ indices in the lower panel. Note that though there is a significant "eclipse-like" drop in light occurring around JD 2449390, the indices remain unaffected. This implies obscuration by dust with properties similar to ISM dust. We find the out-of-eclipse light levels to be 10.57 mag in v and 9.78 mag in b

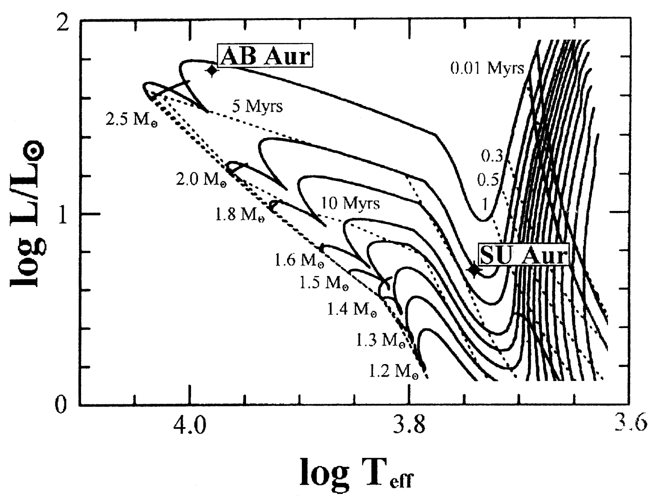

Figure 2. Theoretical Hertzsprung–Russell Diagram (HRD) from D'Antona & Mazzitelli (1994) showing the present positions of both SU and AB Aur. Isochrones are represented by dashed lines within the figure, and the solid lines represent different mass models. Especially noteworthy is their common age of approximately 4 Myrs. Since both stars have similar proper motions, they are most likely a coeval proper motion pair.

star, HD 31305 (A0 V; $V = +7.56$; $B-V = +0.11$). In addition to observing SU Aur, differential photometry of AB Aur was conducted at the same time that SU Aur was observed, but AB Aur was observed less frequently per night and showed only small light variations (± 0.07 in u and ± 0.03 in y).

The usual observing pattern of *sky-comp-var-comp-sky* was employed. An integration time of 10-sec was used and typically the stars were observed several times a night over a 25-30 minute interval. The photometry was reduced in the usual way in that the UT times were converted to heliocentric Julian Day (HJD) and the differential magnitudes were corrected for atmospheric extinction. However, because of the close angular proximity of the stars, the extinction corrections were insignificantly small. Also, the differential Strömgren *uvby* magnitudes were converted to the standard system and Strömgren indices were computed. For the comparison star the following Strömgren magnitudes and indices were adopted: $y = +7.69$, $b-y = +0.06$, $v-b = +0.22$, and $u-v = +1.34$.

Figure 1 shows u(350nm) and y(550nm) light curves of SU Aur for the 1993/94 observing season plotted against Julian Day Number. Also included in the Figure are the Strömgren reddening-free $[c_1]$ and $[m_1]$ indices discussed below. Noteworthy is the large "eclipse-like" drop in light that occurs starting around JD = 2449370 (Jan. 17, 1994 UT) and ending about 40 days later. Also evident are smaller light variations that occur on shorter time-scales and a possible long-term, low amplitude undulation in brightness with time. There is a strong wavelength dependence during the large dimming event of 1994. For example, the magnitude range of the light decrease is 0.75 mag in u, 0.57 mag in v, 0.48 mag in b, and 0.40 mag in y.

To understand better the nature of this light decrease during the large dimming event of 1994, Strömgren reddening-independent $[c_1]$ and $[m_1]$ indices:

$$c_1 = (u - v) - (v - b) \quad and \quad m_1 = (v - b) - (b - y)$$

$$[c_1] = c_1 - 0.20(b - y) \quad and \quad [m_1] = m_1 + 0.32(b - y)$$

(Strömgren, 1966; Crawford & Mandwewala, 1976) were formed from the observations. When plots were made (see Figure 1) of the $[c_1]$ and $[m_1]$ indices versus HJD, no significant variations are seen during the dimming event. We find mean values of $[c_1] = 0.32 \pm 0.046$ and $[m_1] = 0.39 \pm 0.024$ mag. The constancy of the Strömgren indices through the dimming event indicates that the light decrease arises from the obscuration of the star by dust with scattering properties similar to ISM dust. The wavelength dependence of the dimming event as seen with the Strömgren indices appears to eliminate the possibility that the event was produced by a change in the mean temperature of the star from either pulsations or from the sudden growth and decay of large starspots on the star's surface. These other possibilities would have a different wavelength dependence than observed. Since CTTS have accretion disks, the dimming event could be caused by a concentration of matter orbiting in the outer regions of the disk that temporarily obscures the star and the central (hotter) regions of the accretion disk. It is also possible that a dust cloud condenses from ejected matter and temporarily obscures the star.

We also searched for possible short period modulations in brightness that could arise from the rotational modulation of light by starspots. Several T Tau stars have their rotation periods established this way (Bouvier *et al.*, 1995; Bouvier *et al.*, 1993; *cf* Herbst *et al.*, 1994). In particular, we searched for periodic light variability near the 3 day period indicated by Giampapa *et al.* (1993). No evidence for a period near this value was found within these data sets.

Using the Hipparcos parallax given above, we computed the absolute magnitudes of both SU Aur and its nearby companion AB Aur. The reddening correction for both stars was made assuming a value of $E(B-V) = 0.13$ derived from the color indices and spectral type of AB Aur. Using the standard relation $A_V = 3.2\ E(B-V)$, the mean values of $\langle V\rangle_{SU} = +9.23$ and $\langle V\rangle_{AB} = +7.08$, and the Hipparcos distances, we arrive at $M_V = +2.90$ and $(B-V)_0 = +0.70$ for SU Aur and $M_V = +0.87$ and $(B-V)_0 = 0.00$ for AB Aur. These values place SU Aur and AB Aur about 1.8 mag and 0.6 mag above the main-sequence for their respective unreddened colors (or spectral types). The two stars can be satisfactorily placed on PMS evolution tracks (D'Antona & Mazzitelli, 1994) for a common age of about 4 Myrs. Figure 2 shows the locations of SU Aur and AB Aur in the theoretical HRD. This clearly shows that both stars are more luminous than corresponding main-sequence stars. Furthermore, their locations indicate masses of $M_{AB} = 2.5 \pm 0.1\ M_\odot$ and $M_{SU} = 1.9 \pm 0.1\ M_\odot$.

We plan to discuss the photometry of AB Aur in a future paper. Strömgren photometry of both stars is being continued by us with the 0.8m APT. This research is supported by NSF/RUI Grant AST-93 15365, which we gratefully acknowledge.

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LIGHT CURVE CHANGES IN THE ECLIPSING BINARY V719 Her

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The General Catalogue of Variable Stars (Kholopov 1985) lists V719 Her as a probable type c RR Lyrae star with a period of 0.336 days. In the remarks, it is noted that another possibility is that V719 Her is a W UMa eclipsing binary with a period of .67 days. Schmidt (1991; 1993) obtained 15 light curve points in 1989-91 and concluded that V719 Her is indeed a W UMa star but with a period of .400995 days. Goderya, Leung and Schmidt (1996; 1997) subsequently obtained extensive photometry in 1993 which provided timings for five minima over an interval of 78 days. Combining these data with the 1989-91 observations yielded a period of 0.400983 days. However, the resulting O$-$C plot showed a systematic trend in the 1993 data which suggested a shorter period. Goderya *et al.* interpreted this in terms of a period decrease of 0.54 seconds per year which is unusually large for a W UMa star.

In an attempt to verify the large period change, further VR photometry was conducted on four nights in 1995 and 16 nights in 1997. The observations were all obtained with the CCD camera on the Behlen Observatory 0.76-m telescope. The observation and reduction techniques were the same as described by Schmidt (1991). We used the same comparison stars as Goderya, Leung and Schmidt (1996) but redetermined the mean magnitudes and colors using a total of twelve photometric nights. The values are given in Table 1 and are accurate to better than 0.01 magnitudes.

Table 1. Photometric Indices for V719 Her and its Comparison Stars

Star	V	R	$V-R$
V719 Her	12.51	12.12	0.40
C1	14.03	13.51	0.52
C2	14.48	14.13	0.35

More than 200 new light curve points were obtained. The individual observations have been placed in the IAU Archives of Unpublished Variable Star Observations (file number 333E) or they can be obtained from the author.

When the new observations were plotted it was apparent that they did not fit the elements derived by Goderya *et al.* with a decreasing period. Therefore, all of the observations were used to redetermine the period with the data corrected discrete Fourier method (Ferraz-Mello, 1981). Although this method is not well suited to eclipsing stars in general, it will produce useful periods for W UMa stars where the maxima are rounded. The period obtained in that way was then doubled (since there are two minima per cycle while the DCDF method searches for one) and adjusted to minimize scatter in the light curve. The resulting period was 0.400928 ± 0.0000015 days.

All of the data is plotted in Figure 1 with this period. It is immediately obvious that a single period is valid over the entire interval from 1989 to 1997. Thus, the period variation suggested by Goderya *et al.* was spurious. Since the depths of the minima vary (see below) it is possible the erroneous period was due in part to difficulties in distinguishing between the two minima. With the current expanded data set, the ambiguity is resolved.

In examining Figure 1, it can be seen that there is a range of 0.10 to 0.15 magnitudes in the brightness throughout the light curve. Most of this range arises because the object was brighter in 1997 than earlier. However, even during one season the scatter at some phases is larger than observational error. We can eliminate difficulties with comparison stars as the source of the scatter since there are two comparison stars which agree at the level of 0.012 in V and 0.013 in R both during one season and over the longer term.

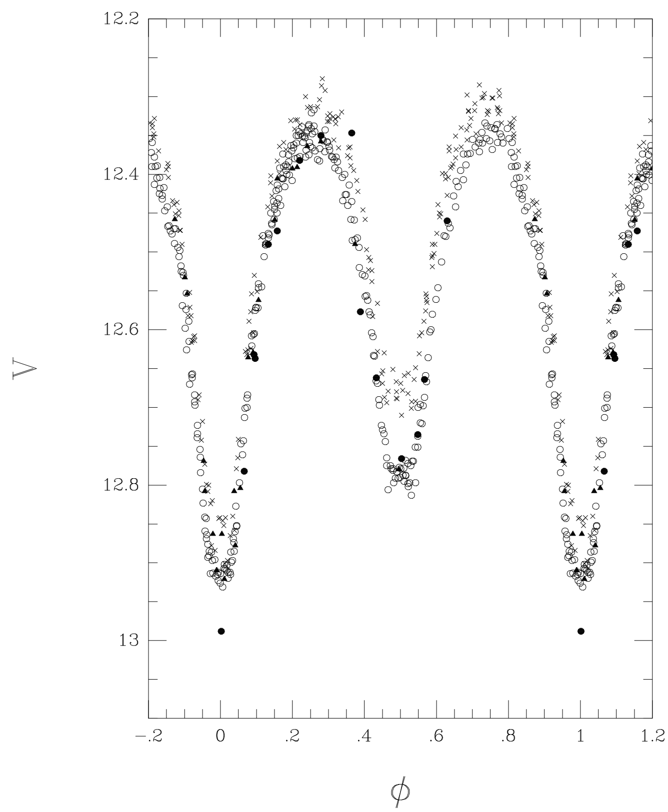

Figure 1. The light curve of V719 Her. The various symbols indicate the year of the observation as follows: filled circles, 1989-91; open circles, 1993; triangles, 1995; X's, 1997.

The brighter magnitudes in 1997 might be accounted for by the presence of a third star which had increased in brightness, by the brightening of one of the stars in the binary or by large spots one one or both of the stars. The first possibility does not seem likely because the increased brightness in both minima cannot be accounted for simultaneously. On the other hand, since the smaller star is eclipsed totally during the secondary minimum (since it has a flat bottom), the larger star would need to be the variable if the second explanation is correct. To a first approximation this model fits the fact that the brightening during primary minimum and at maximum is approximately the same and the brightening during secondary minimum is larger. However, a more detailed analysis which considered the scatter within a given season as well as the longer term variations is needed to verify this hypothesis. To evaluation of the third alternative would require detailed modelling with a larger data set.

Although the unusually large period change which originally motivated this study proved to be incorrect, the light curve variations make this an interesting star which should be studied further.

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ON THE RECENT NOVA IN NGC 205

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Qiao et al. (1997) reported the discovery of a nova in NGC 205 in the course of the Beijing Astronomical Observatory supernova survey. They derived unfiltered CCD magnitudes of the nova on three nights in succession, and on one of the nights obtained a low-resolution spectrogram which showed features typical of novae after maximum.

We estimated the brightness of the Nova on plates taken for search of novae in M 31 with the Baldone 80-cm Schmidt telescope of the Institute of Astronomy, University of Latvia, and with the 50-cm Maksutov telescope at the Crimean Laboratory of the Sternberg Astronomical Institute of the Moscow University.

The dates, times of the middle of exposure in Julian days, and B-magnitudes of the Nova based on the photometric sequences in the central region of M 31 (Rosino et al., 1989) are given in Table 1.

Table 1

Date, 1997	JD 2450000+	B
Nov 5/6	758.300	(19.
Nov 5/6	758.340	(19.9
Nov 9/10	762.482	(19.5
Nov 20/21	773.242	17.8
Nov 20/21	773.319	18.0
Nov 24/25	777.217	18.5
Nov 28/29	781.194	19.0::
Dec 1/2	784.406	19.3::
Dec 5/6	788.377	19.3:
Dec 5/6	788.464	(19
Dec 16/17	799.187	(19.5
Dec 19/20	802.191	(19.9
Dec 19/20	802.227	20.1

From the nearly simultaneous (Nov. 23.4 and Nov. 23.44 UT) $V = 18.1$ and unfiltered m(CCD) = 18.5 magnitudes (Qiao et al., 1997) and the average intrinsic colour index

$B - V = 0.23$ for novae at maximum light (van den Bergh and Younger, 1987) we derive $B - m(\mathrm{CCD}) = -0.17$, and from magnitudes by Qiao et al. we obtain estimates of B-magnitudes of the Nova: 18.6 at JD 2450774.04, 18.2 at 0775.00, and 18.3 at 0775.92, values that on the average fit well to our light curve.

The available photometric data for the Nova do not allow to determine time and value of the maximum brightness exactly. However, the Nova was at least as bright as $B = 17.8$, and probably 17.4 or even brighter (see Figure 1). In the case of the mentioned alternatives, the estimated rate of decline is $\log(100d) = 0.94$ and $\log(100d) = 1.03$, which corresponds to the fast novae according to the classification by Payne-Gaposchkin (1957).

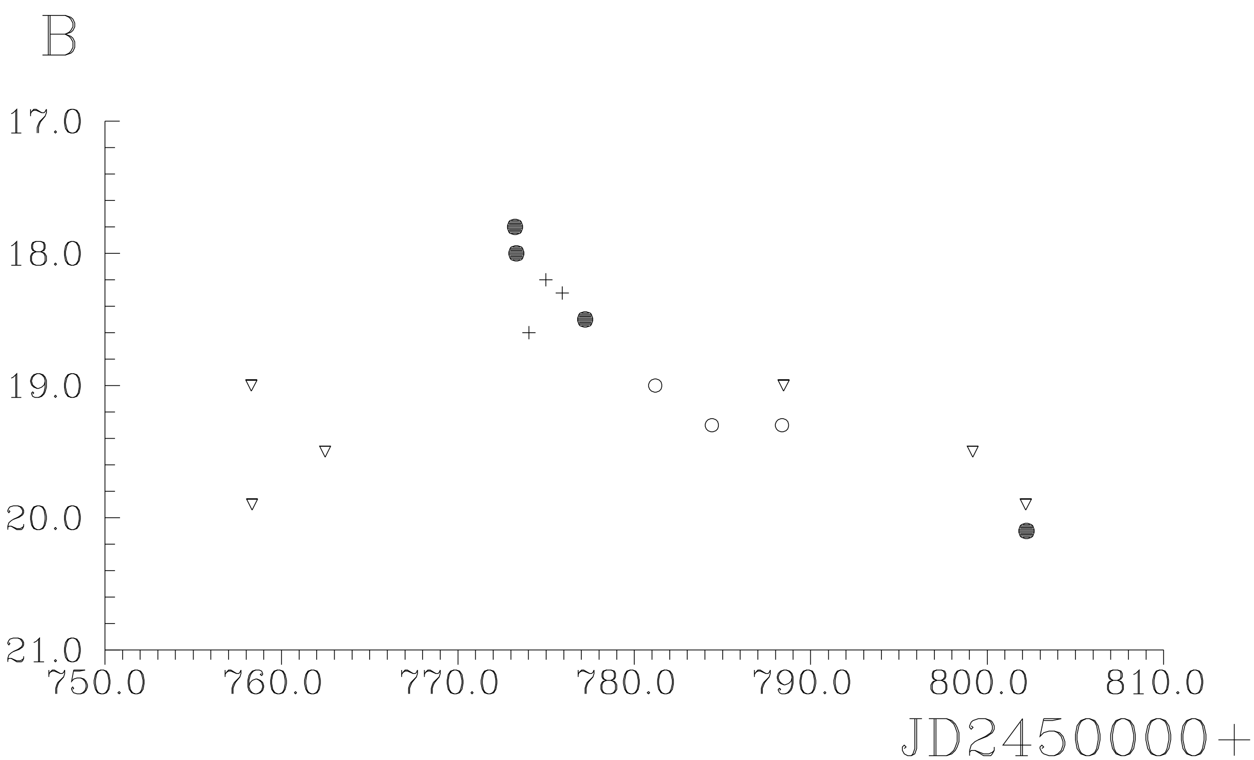

Figure 1. The light curve of the nova in NGC 205. Filled circles: our confident measurements; open circles: our uncertain measurements; triangles: our bright limits; crosses: measurements by Qiao et al. reduced to B magnitudes by us.

It is difficult to prove that this Nova really belongs to NGC 205. If we suppose that the Nova is located in the main plane of the galaxy M 31, then the Nova's distance from its center is about 31 kpc, as large as that of another very distant Nova ShA 39 in M 31 (Sharov and Alksnis, 1995).

According to measurements by Yu.A. Shokin, the coordinates of the Nova are the following:

$$\alpha_{1950.0} = 0^{\mathrm{h}}37^{\mathrm{m}}39\overset{\mathrm{s}}{.}478$$
$$\delta_{1950.0} = +41^{\circ}27'00\farcs05$$

The Nova is the second known nova in the region of NGC 205. The first one was discovered by Zwicky (1957) $7'$ north from the center of NGC 205 on September 21, 1955. However, no details were published.

We wish to thank Yu.A. Shokin for determining the coordinates of the Nova. One of the authors (A.Sh.) is also grateful to the Russian Foundation for Basic Research and to the Council of the Program for the Support of Leading Scientific Schools (grants 95-02-03942 and 96-15-96656).

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BI CVn: A STUDY OF ITS PERIOD AND A NEW PHOTOELECTRIC LIGHT CURVE

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BI CVn ($13^h03^m17^s$; $+36°37'.1$; 2000.0) is an eclipsing binary on which no detailed study is published even if the GCVS states that its period is suspected to be variable. For this reason the star was included in the observing programme carried out by the GEOS using the 76–cm telescope of Geneva Observatory located on the Jungfraujoch. 43 measurements were obtained in B and V filters of the Geneva system during several missions, devoted to the systematic observations of neglected variable stars. Moreover, the GEOS continued to monitor the star visually.

76 new minima were collected (13 photoelectric, 4 CCD in V–light, 4 CCD in white light, 43 visual, 12 photographic). 49 of them were already published (Vandenbroere 1996; a copy can be requested from the GEOS), 6 are reported by Liu and Tan (1988). Table 1 lists all the CCD and photoelectric minima observed photoelectrically by GEOS, by Franz Agerer using CCD with a V filter and by Anthon Paschke using CCD in white light.

Table 1. Recent photoelectric and CCD times of minima of BI CVn

Type of minima	HJD 2400000+	Method	Type of minima	HJD 2400000+	Method
I	49137.486	CCD	I	49761.4375	CCD V
I	49479.430	CCD	II	49761.6308	CCD V
II	49516.508	CCD	II	50152.3673	CCD V
I	49722.6325	p.e.	I	50152.5589	CCD V
II	49810.4258	p.e.	I	50252.453	CCD

The GCVS reports a period of $0^d.3846$ (see also Zhukov 1982 and 1986), but the related ephemeris cannot be used further to predict times of minima. Several attempts were made to rely on all the available minima (see Vandenbroere 1996 for a detailed discussion), but large O−C's were obtained, strongly suggesting a period change. In particular, two different periods are necessary to fit the minima before and after JD 24 445 760. The resulting ephemeris valid after this date is

$$\begin{array}{lllll} \mathrm{Min\,I} = & \mathrm{HJD} & 2445769.538 & + & 0^d.3842059 \times E \\ & & \pm 0.002 & & \pm 0.0000004 \end{array}$$

while before this date a period of $0^d.3842120$ was calculated. The difference between the depths of the primary and the secondary minima is very small and only the good–quality photoelectric data collected at Jungfraujoch allowed us to distinguish between them (Figure 1). The above ephemeris predicts primary minima according to this distinction.

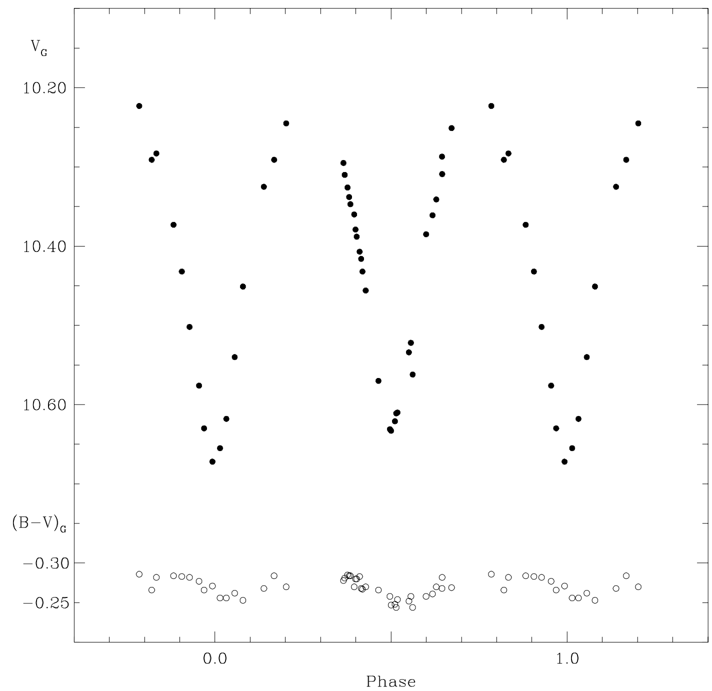

Figure 1. V and B−V (Geneva system) phase curves of BI CVn

From the 43 new BV measurements carried out in the Geneva photometric system we found that BI CVn is ranging from $10^{\rm m}.22$ to $10^{\rm m}.67$ in V light (Minimum II $10^{\rm m}.63$ at phase 0.5), while $(B-V)_G$ varies from $-0^{\rm m}.29$ to $-0^{\rm m}.24$, which corresponds to a range $0^{\rm m}.55$–$0^{\rm m}.59$ in $(B-V)_J$. The $B-V$ colour curve does not mimic perfectly the V light curve, suggesting some surface irregularities as spots. The comparison with the previous photoelectric curves also suggests some little changes in the shape; this fact, combined with the period change surely occurred in the past, makes BI CVn an interesting object for further studies. It should be noted that different classifications as a W UMa system can be found in the literature: W subclass according to Demircan (1987), A subclass according to Maceroni and Van't Veer (1996).

Recently Rucinski and Duerbeck (1997) supplied a M_V calibration for the W UMa stars based on the Hipparcos data. They emphasized that one of the limitations of the calibration is the inadequate quality of the ground–based photometric data, especially the $B-V$ index value. Since in our photometric run we always performed a careful transformation by measuring a lot of standard stars, the mean $(B-V)_J$ value we obtained ($0^{\rm m}.57$) is as good as the transformations from the Geneva to Johnson systems are. By the above quoted values, we derived M_V=3.68, in excellent agreement with the Rucinski and Duerbeck sample.

Table 2. New photoelectric measurements of BI CVn in the Geneva system

HJD 2440000+	V	B–V	HJD 2440000+	V	B–V
9715.5806	10.309	−0.282	9810.3762	10.326	−0.285
9721.6957	10.562	−0.244	9810.3779	10.338	−0.284
9721.7214	10.341	−0.270	9810.3793	10.347	−0.284
9722.5499	10.223	−0.286	9810.3835	10.360	−0.270
9722.5686	10.283	−0.282	9810.3849	10.379	−0.280
9722.5874	10.373	−0.284	9810.3862	10.388	−0.280
9722.5964	10.432	−0.283	9810.3894	10.407	−0.283
9722.6048	10.502	−0.282	9810.3911	10.416	−0.268
9722.6152	10.576	−0.277	9810.3925	10.432	−0.267
9722.6207	10.630	−0.266	9810.3960	10.456	−0.270
9722.6298	10.672	−0.271	9810.4099	10.570	−0.266
9722.6381	10.655	−0.256	9810.4224	10.631	−0.258
9722.6450	10.618	−0.256	9810.4237	10.633	−0.247
9722.6541	10.540	−0.262	9810.4279	10.621	−0.248
9722.6631	10.451	−0.253	9810.4293	10.611	−0.244
9722.6860	10.325	−0.268	9810.4307	10.610	−0.254
9722.6971	10.291	−0.284	9810.4432	10.534	−0.252
9722.7103	10.245	−0.270	9810.4453	10.522	−0.258
9807.3953	10.361	−0.261	9810.4619	10.385	−0.258
9807.4731	10.291	−0.266	9810.4793	10.287	−0.268
9810.3717	10.295	−0.278	9810.4897	10.251	−0.269
9810.3731	10.310	−0.281			

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PHOTOELECTRIC AND CCD TIMES OF MINIMA OF 19 ECLIPSING BINARY SYSTEMS

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We present photoelectric and CCD photometric minima observations of 19 eclipsing binary systems. Most of them are stars with apsidal motion or at least eccentric binary systems, selected from the listing of Hegedüs (1988). Some minima observations (e.g. for UZ Leonis) are part of complete light curve coverages.

One part of the photoelectric observations was carried out at Piszkéstető Mountain Station of the Konkoly Observatory of the Hungarian Academy of Sciences with a 20 in. f/15 Cassegrain telescope. The photometer used was equipped with an unrefrigerated EMI9058QB photomultiplier tube and Schott UG2 (for U), BG12+GG13 (for B) and GG11 (for V) filters. This system is referred to as Pi50 in Table 1. The other part of the photoelectric measurements was made at Baja Astronomical Observatory with a Starlight-I photometer, equipped with an unrefrigerated EMI9924A multiplier tube and Schott filters UG1 (matching Johnson's U), GG400+BG25 (matching B) and OG515 (matching V), mounted on the 20 in. f/8.4 Ritchey-Chrétien telescope (Ba50 in Table 1). The unfiltered CCD observations were carried out with an ST-5 (1995-96), and an ST-7 (1997) camera installed on the 20 in. RC telescope mentioned above.

The observations were made between 1995-1998. Reduction of the photoelectric data was made by standard procedures. For the reduction of the CCD frames we used the IRAF package. All the minima times were computed using the parabolic fitting method.

Table 1 presents the derived minima times. The content of the first two columns is self-explaining. The error in the last digit appears in the third column. In the fourth column the types of minima are marked (I for primary, and II for secondary ones), while in the fifth column the number of individual data involved in the parabolic fit is given. The columns from sixth to eighth describe the filters used, the first three letters of the observers' names and the codes of the instrumentation. The last column contains the comparisons used, identified by their BD, GSC or HD numbers.

Table 1

Star	Min. HJD +2400000	error ±	Min. type	Points used	Filter	Obs.'s name	Instr.	Comp.
AS Cam	50519.5178	2	II	78	-	Bor	Ba50 (ST7)	GSC 4347-0466
RZ Cas	50247.5014	8	I	91	-	Bor	Ba50 (ST5)	GSC 4317-1437
	50815.2545	1	I	51	V	Par+Bor	Pi50	BD+67°215
	50815.2541	6	I	48	B	Par+Bor	Pi50	
PV Cas	50244.4443	3	II	134	-	Bor	Ba50 (ST5)	GSC 4010-1545
	50279.4665	1	II	40	V	Bir	Pi50	BD+58°2555
	50279.4667	4	II	40	B	Bir	Pi50	
VW Cep	50171.4028	3	I	18	V	Bor	Pi50	BD+75°765
	50171.4030	4	I	18	B	Bor	Pi50	
	50171.402	1	I	19	U	Bor	Pi50	
	50171.5410	3	II	27	V	Bor	Pi50	
	50171.5418	1	II	27	B	Bor	Pi50	
	50171.543	1	II	27	U	Bor	Pi50	
XX Cep	50297.445	1	I	71	V	Bir	Pi50	BD+63°2030
	50297.446	1	I	68	B	Bir	Pi50	
GK Cep	50210.451	2	I	146	-	Bir	Ba50 (ST5)	GSC 4465-1764
	50225.4286	5	I	81	-	Bir	Ba50 (ST5)	
MR Cyg	50230.4597	2	I	104	-	Bor	Ba50 (ST5)	GSC 3609-1293
V453 Cyg	50235.4809	5	I	628	-	Bir	Ba50 (ST5)	GSC 2683-3541
V477 Cyg	50237.4445	2	I	120	-	Bir	Ba50 (ST5)	GSC 2674-0910
V836 Cyg	49919.4008	5	I	34	-	Par	Ba50 (ST5)	GSC 2715-0017
V1136 Cyg	50270.4672	4	I	83	-	Bir	Ba50 (ST5)	GSC 2150-3445
AK Her	50275.4763	3	I	47	V	Bor	Ba50	BD+16°3123
	50275.474	1	I	48	B	Bor	Ba50	
	50310.4582	5	I	32	V	Bor	Ba50	
	50310.4574	2	I	32	B	Bor	Ba50	
	50508.574	1	I	102	-	Bor	Ba50 (ST7)	GSC 1536-0928
	50512.5802	2	II	83	-	Bor	Ba50 (ST7)	
CC Her	49876.4996	3	I	38	-	Par	Ba50 (ST5)	GSC 0946-1166
DI Her	50238.4879	5	II	135	-	Bir	Ba50 (ST5)	GSC 2109-1273
UV Leo	50499.4473	4	I	44	V	Bor	Pi50	BD+14°2277
	50499.4471	2	I	44	B	Bor	Pi50	
	50513.5375	3	II	33	-	Bor	Ba50 (ST7)	GSC 0845-0136
UZ Leo	50507.445	2	I	18	V	Heg	Pi50	BD+14°2279
	50509.606	1	II	27	V	Heg	Pi50	
	50509.607	1	II	26	B	Heg	Pi50	
	50510.5361	9	I	16	V	Heg	Pi50	
	50510.5386	6	I	16	B	Heg	Pi50	
	50512.3872	1	I	24	V	Heg	Pi50	
	50512.388	1	I	21	B	Heg	Pi50	
FT Ori	50494.3442	5	I	36	V	Bor	Pi50	BD+22°1250
	50494.3446	3	I	36	B	Bor	Pi50	
ST Per	50813.330	1	I	54	V	Bor+Par	Pi50	HD 18615
	50813.3301	6	I	47	B	Bor+Par	Pi50	
U Sge	50287.5178	9	I	79	V	Bor	Ba50	BD+19°3976
	50287.5184	7	I	79	B	Bor	Ba50	

Remarks on some of the variables:
XX Cep: This Algol-system is an apsidal motion candidate star (e.g. Hegedüs, 1988), but recently Borkovits and Hegedüs (1996) tried to explain its period variation by light-time effect. The new times of minima (see also Hegedüs et al. 1996) do not support their solution.
AK Her: The new times of minima are also inconsistent with the light-time solution of Borkovits and Hegedüs (1996).
CC Her: This minimum time was already published in Hegedüs et al. (1996), but there we missed the correction for Daylight Saving Time (DST), and the GSC number of the comparison was also incorrect. These are the correct data.

PV Cas: The initial comparison candidate star for PV Cassiopeiae, GSC 4010-1432, showed variations of about 0.8 mag against the check star GSC 4010-1545, and some other fainter stars in the CCD frame.

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ERRATA

In IBVS Nos. 4555 and 4633 we presented CCD photometric minima observations (together with photoelectric ones) of several eclipsing binary systems. Due to an unfortunate programming bug most of the minimum times have an error in the third decimal place of JD. This erratum contains the corrected moments of minima. Table 1 shows the corrigenda to IBVS No. 4555. Table 2 should be used as a total replacement of the Table of IBVS No. 4633.

Table 1

Star	Min. HJD +2400000	Star	Min. HJD +2400000
AS Cam	50519.5238	V453 Cyg	50235.4843
PV Cas	50244.4435	V477 Cyg	50237.4480
GK Cep	50210.453	V1136 Cyg	50270.4694
	50225.4297	DI Her	50238.4929
MR Cyg	50230.4608	UV Leo	50513.5487

Table 2

Star	Min. HJD +2400000	error ±	Min. type	Points used	Filter	Obs.'s name	Instr.	Comp.
RT And	50964.5050	2	I	51	V	Bir	Ba50	HD 218915
AB And	50966.5525	3	II	30	V	Bir	Ba50	GSC 2763-0683
	50984.4721	4	II		V	Bir	Ba50	
	51016.5005	1	I	41	V	Bor	Ba50	
OO Aql	50950.486:	1	I	19	V	Bor	Ba50	HD 187146
	50956.5658:	2	I	61	V	Bir	Ba50	
	50967.4659	1	II	45	V	Bor	Ba50	
Y Cam	50872.4672	3	I	77	-	Bor	Ba50	GSC 4527-1983
AS Cam	50900.351	1	II	163	V	Bor	Ba50	GSC 4347-0466
RZ Cas	50871.4318	3	I	414	-	Bor	Ba50	GSC 4317-1578
TV Cas	51005.45:	1	II	190	V	Bir	Ba50	GSC 3665-0026
PV Cas	51015.5244	5	I	55	V	Bir	Ba50	GSC 4010-1432
VW Cep	50871.6279	5	I	102	-	Bor	Ba50	GSC 4585-2387
	50900.5736	3	I	54	V	Bor	Ba50	
	50941.3443	3	II	51	V,B,R	Bor	Ba50	
	50941.4859	3	I	61	V,B,R	Bor	Ba50	
	50942.4573	5	II	59	V,B,R	Bir	Ba50	
	50942.5990	5	I	28	V,B,R	Bir	Ba50	
XX Cep	51018.517:	6	II	91	V	Bor	Ba50	GSC 4288-0186
CQ Cep	50948.5431	6	I	200	V	Bir	Ba50	GSC 3991-1316
DL Cyg	51038.485	3	I	170	V,R	Bor	Ba50	GSC 3595-0816
MR Cyg	50962.4954	1	II	87	V	Bir	Ba50	GSC 3609-1220
	51014.4830	5	II	124	V	Bir	Ba50	
V477 Cyg	50974.4054	2	I	53	V	Bor	Ba50	GSC 2674-0910
AK Her	50865.6038	2	I	53	V,B	Bir	Pi50	BD+16°3123
	50866.6601	1	II	78	-	Bor	Ba50	GSC 1536-0928
	50884.5722	2	I	82	V	Bor	Ba50	
	50903.5413	3	I	78	V	Bir	Ba50	
	50971.4060	3	I	266	R	Bor	Ba50	

Table 2 (cont.)

Star	Min. HJD +2400000	error ±	Min. type	Points used	Filter	Obs.'s name	Instr.	Comp.
GU Her	50970.434	2	I	215	-	Bor	Ba50	GSC 2581-2418
	50983.4675	3	I	200	-	Bir	Ba50	
	51033.421	4	II		-	Bir	Ba50	
HS Her	50945.4749	2	I	283	V	Bir	Ba50	GSC 2113-2242
	50972.4946	3	II	343	V	Bir	Ba50	
	50981.5011	3	I	125	V	Bir	Ba50	
MM Her	50940.5670	5	I	182	V	Bir	Ba50	GSC 1565-2199
SW Lac	50961.518	1	II	49	V	Bir	Ba50	GSC 3215-0906
	50986.5358	1	II	54	V	Bir	Ba50	
	51017.4831	1	I	35	V	Bor	Ba50	
UV Leo	50899.4051	1	II	60	V	Bir	Ba50	GSC 0845-0121
GP Vul	50946.4643	8	II	65	V	Bir	Ba50	GSC 2151-2731

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A NEW DOUBLE-MODE CEPHEID IN CASSIOPEIA

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In the course of the search for new classical Cepheids on Moscow archive plates, a new double-mode Cepheid (GSC 4015.0972; $\alpha = 0^{\mathrm{h}}25^{\mathrm{m}}18^{\mathrm{s}}.2$, $\delta = +60^\circ 45' 54''$ (J2000.0); $l = 119^\circ.7$, $b = -1^\circ.9$) was discovered. Note that the star was marked as a non-stellar object in the Guide Star Catalogue. The reason, possibly, is that this variable has a fainter north-western neighbouring star, so it is double.

GSC 4015.0972 was estimated by eye on 536 plates taken with the 40-cm astrograph for the interval from JD2437284 to 49933. B-band magnitudes of comparison stars were obtained based on the standard sequence in NGC 129 (Hoag et al., 1961). The range of variability is $14^{\mathrm{m}}.10 - 14^{\mathrm{m}}.95$. The comparison star b seems to be variable with a very small amplitude. On several plates it seems to become a little fainter than usually. In these cases, the comparison star b' was used to make the estimates. Finding chart and comparison stars are shown in Figure 1.

Frequency analysis shows the existence, in the spectrum, of two strong peaks at frequencies f_0 and f_1, and their day aliases (Fig. 2). The step in frequency is about $8 \cdot 10^{-6}$ c/d.

The periods and their ratio ($f_0/f_1 = P_1/P_0 = 0.7103$) led us to the classification of GSC 4015.0972 as a new double-mode Cepheid. The light elements are the following:

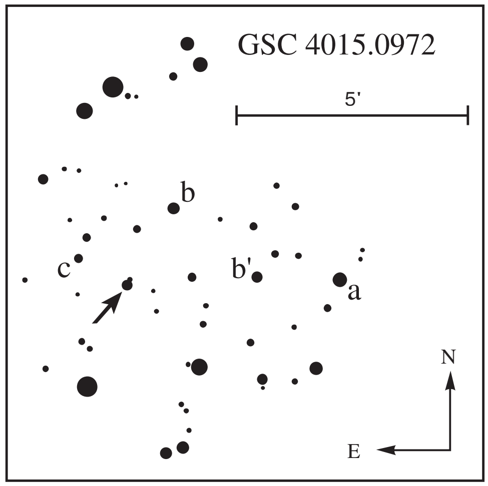
$$\mathrm{JD_{max}} = 2443784.37 + 3^{\mathrm{d}}.73425 \times E \text{ (fundamental mode) and}$$

$$\mathrm{JD_{max}} = 2444825.50 + 2^{\mathrm{d}}.65262 \times E \text{ (first overtone mode).}$$

In our case of power spectrum the peaks at coupling terms ($f_1 + f_0$ and $f_1 - f_0$) and at higher multiples ($2f_0$, $2f_1$ etc.) are almost absent. As mentioned by Alcock et al. (1995), this situation is possible if the shapes of the phased light curves are nearly sinusoidal. Phased light curves presented in Figure 3 confirm their statement. Figures 3a and 3b are based on the original estimates, Figures 3c and 3d are constructed for deviations from the mean phased light curve of the other oscillation. The peaks in the spectrum at f_0 and f_1, and the amplitudes of both pulsations ($A_0 \sim 0^{\mathrm{m}}.40$, $A_1 \sim 0^{\mathrm{m}}.38$) are almost equal.

Finally, we found a new relation between the period ratios P_1/P_0 and $\log_{10} P_0$ (Fig. 4). This relation is based on the data on fifteen Galaxy's double-mode Cepheids that pulsate in fundamental and first overtone modes. The data on fourteen beat Cepheids was taken from McMaster Cepheid Photometry and Radial Velocity Data Archive maintained by Dr. Welch. The new variable became the fifteenth one in our sample. The best fit now is:

$$P_1/P_0 = 0.722 - 0.030 \times \log_{10} P_0, \quad 0.3 < \log_{10} P_0 < 0.8.$$



Star	B_{pg}
a	13.65
b	14.28
b'	14.38
c	14.89

Figure 1. The finding chart and the comparison stars

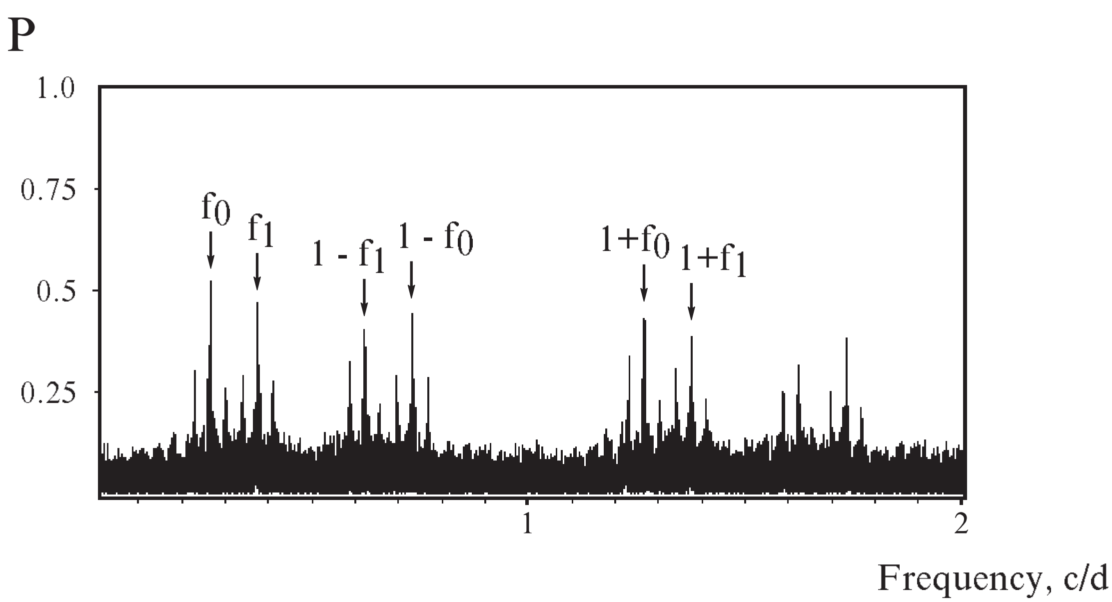


Figure 2. The power spectrum

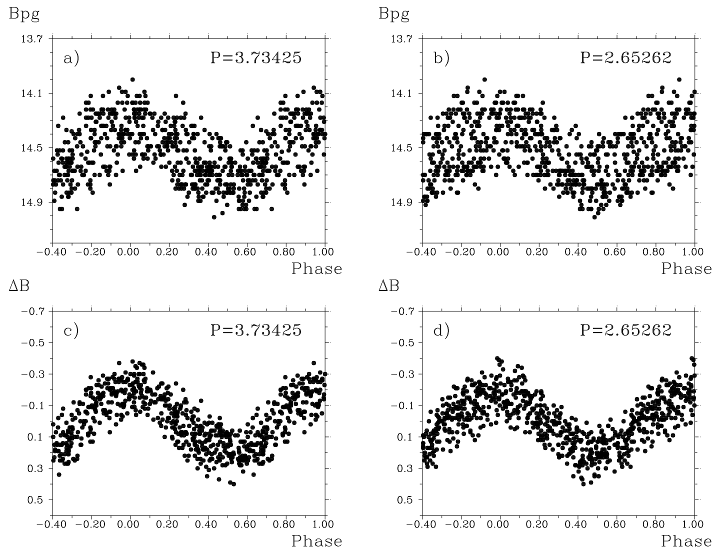


Figure 3. The phased light curves: a) the fundamental mode; b) the first overtone mode; c) the fundamental mode where the first overtone has been whitened; d) the first overtone where the fundamental mode has been whitened

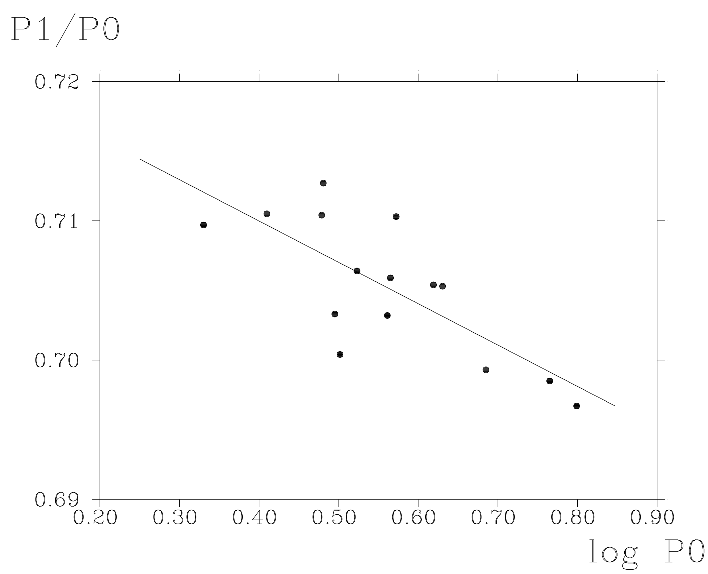


Figure 4. The relation between the ratio P_1/P_0 and $\log_{10} P_0$ for Galaxy's double-mode Cepheids

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HIP 12056 IS AN ECLIPSING BINARY SYSTEM

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HIP 12056 (SAO 38145 = PPM 45234 = HD 15965 = BD +45°628 = AGK +45°0275 = GSC 3295.2164) was observed by the HIPPARCOS satellite and found variable, and it was listed among the unsolved variable stars (ESA, 1997). According to the HD catalogue, this object is an A star, while it is listed as a B8 type star in the PPM.

The analysis of the HIPPARCOS photometric data showed that HIP 12056 is actually an eclipsing binary system with a period over two days and a maximum V magnitude of 9.19 ±0.01 (Figure 1). To obtain more information about it, the star was monitored in the V band, from 21 August to 14 December 1997, at Monegrillo Observatory using the 0.4-m Newtonian telescope. SAO 38137 was used as comparison star, with $V=8\overset{m}{.}235$ as calculated from Tycho magnitudes.

Observations show that HIP 12056 is an eclipsing binary system with a period close to 2.165 days. Figure 2 depicts the folded light curve. At primary minimum, the star fades by 0.18 magnitudes. The secondary minimum is 0.16 magnitude deep. HIPPARCOS data provided a primary minimum that was taken as zero epoch. The final derived ephemeris is the following:

$$\text{Min. I} = \text{HJD } 2448430.0254 + 2\overset{d}{.}165016 \times E$$
$$\pm 0.0040 \quad \pm 0.000010$$

The combined set of satellite data and CCD observations allowed to compute the time of eight minima, using Kwee and van Woerden's (1956) method, and the respective O−C residuals, all of them summarized in Table 1.

Table 1

HJD +2400000	Epoch	O−C
48430.0060	0.0	−0.0195
48431.1221	0.5	+0.0142
48433.2533	1.5	−0.0196
48617.2801	86.5	−0.0192
50718.4493	1057.0	+0.0020
50731.4443	1063.0	+0.0069
50795.3130	1092.5	+0.0076
50796.3950	1093.0	+0.0071

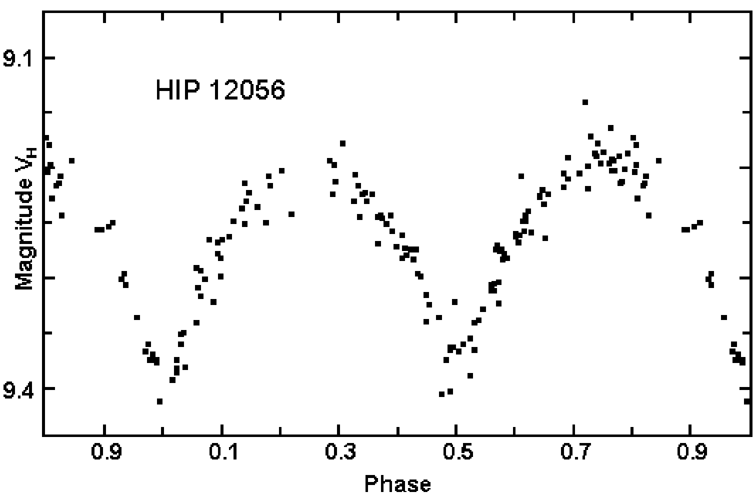

Figure 1. Light curve of HIP 12056 derived from the original satellite data folded according to the given ephemeris

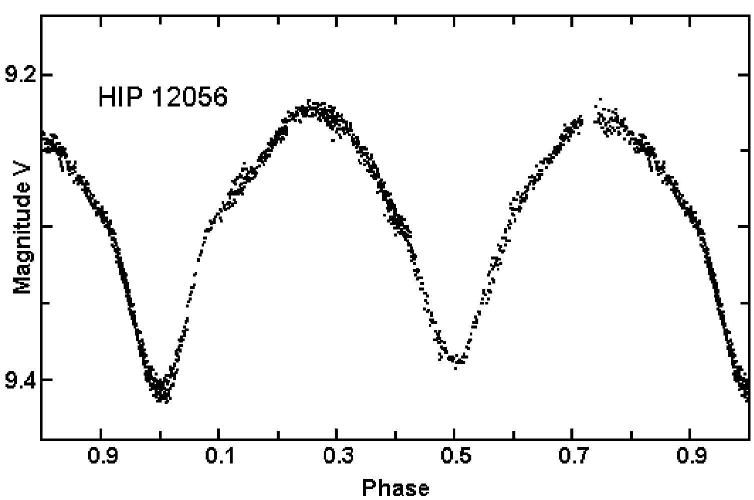

Figure 2. Photometric observations of HIP 12056 phased according to the given ephemeris

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ECLIPSE OBSERVATIONS OF AM Tau

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AM Tau (B8, V=10.4, $05^{\rm h}52^{\rm m}21\overset{\rm s}{.}37$, $+16^\circ17'00''$, J2000) is a relatively bright but poorly studied eclipsing binary with a period of 2.04 days. A physical model for the system was determined by Brancewicz and Dworak (1980), but it was made on the basis of previous published spectral types, rather than a fit to the light curve. A linear ephemeris is also given in the SAC No. 67 (Danielkiewicz-Krosniak and Kurpinska-Winiarska, 1996, hereafter DK96). This note presents new observations of the time of primary eclipse, leading to an improved period estimate. We also present a simple physical model derived from a least-squares fit to the observed light curve.

We observed AM Tau using the University of Iowa's Automated Telescope Facility located in Iowa City, IA. The system consists of an 18cm refractor, a Spectrasource HPC-1 CCD camera (format 512×512 binned pixels, $3\overset{''}{.}00$ per pixel) and a Johnson R-band filter. We used the nearby stars GSC1312-2704 and GSC1299-0984 (R=10.05) as check and calibration stars, respectively. Each observation consisted of 50 second exposures of a 26.5×26.5 arcmin field containing AM Tau as well as the check and comparison stars. For each observing session, the exposures were repeated every 2 minutes for approximately two hours. Differential aperture photometry was performed by an automated procedure after aligning all images to a common reference. No color or air mass corrections were applied. We estimate that this results in less than 0.05 magnitude error using an R filter.

The five observing sessions occurred on 25, 29, 30 Sep 1997, 22 Oct 1997, and 25 Nov 1997. The observed time of primary minimum was HJD = 2,450,716.8098±0.0005. This implies a period P=2.043918±0.000002 days, using a reference time of primary minimum JD0=2,445,253.417 (DK96). Our period differs significantly from the value quoted by Danielkiewicz-Krosniak and Kurpinska-Winiarska (1996), P=2.043926 days. By combining all five observations, the basic shape of the light curve shown in Figure 1 was obtained. The data was fitted with a simple geometric model using spherical stars, circular orbits, and no limb darkening. Our data is represented with the solid line, while the calculations of Brancewicz and Dworak are used to plot a second light curve in the same figure with a dotted line for reference. Table 1 below summarizes the best-fit stellar parameters shown in Figure 1.

Table 1. AM Tau Model Parameters

Parameter	BD80	This Paper
Luminosity Ratio L2/L1	0.185	0.10
Ratio of Radii R2/R1	1.11	0.8
Ratio of Sep'n to R1	6.32	4.50
Inclination Angle	(90)°	90°

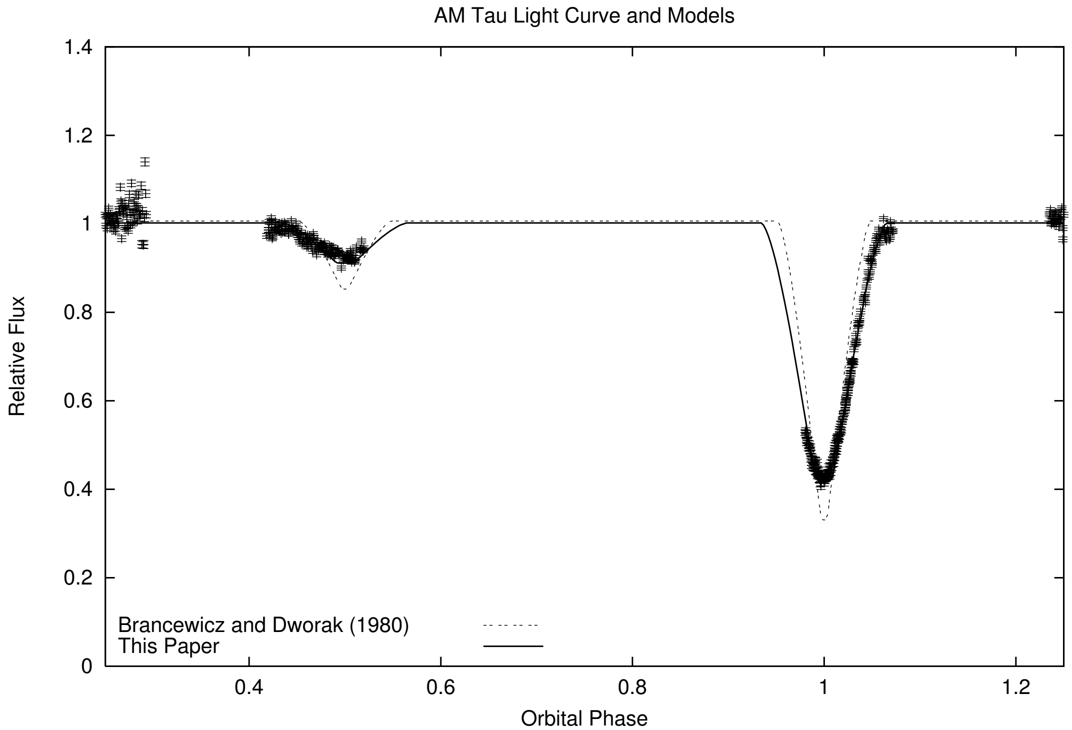

Figure 1. Observed light curve of AM Tau made by combining all five observations. The solid line is the expected light curve given by the model of this paper (Table 1), while the dotted line is from the model of Brancewicz and Dworak (1980)

This research has been supported by the Iowa Space Grant Consortium and the National Science Foundation. We have also made use of the Simbad database, operated at CDS, Strasbourg, France.

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ECLIPSE TIMING OBSERVATIONS OF THREE CLOSE BINARIES

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T Leonis Minoris, EQ Tauri, and WW Cygni are frequently observed close eclipsing binaries. These systems are on the AAVSO list of eclipsing binaries (Baldwin and Samolyk 1993). The AAVSO database of O−C observations (largely from visual timings) showed some evidence for either period changes or incorrect periods in all three systems.

The present note describes CCD photometry of T LMi, EQ Tau, and WW Cyg using the University of Iowa's Automated Telescope Facility located in Iowa City, Iowa. The system consists of an 18cm refractor, a Spectrasource HPC-1CCD camera (format 512×512 binned pixels, $3''\!.00$ per pixel), and a Johnson R-band filter. A series of 60 second exposures of a field containing the target star as well as check and comparison stars was repeated every two minutes for three hours. Differential aperture photometry was performed by an automated procedure after aligning all images to a common stellar reference. No air mass or color corrections were applied. At R band, we estimate this will introduce errors less than 0.05 mag.

The central time and uncertainty of each eclipse minimum was determined by a least-squares algorithm which 'folds' the light curve about the center of the eclipse, i.e. setting the heliocentric Julian date (HJD) at the time of minimum to zero and plotting the differential magnitude versus the absolute value of the HJD to produce a folded light curve for each night. As our original curves were almost perfectly symmetric, any shift in the minimum HJD greater than ± 0.0005 HJD caused noticeable discrepancies between the two halves.

For all three stars, we used the published ephemerides given by Danielkiewicz-Krosniak and Kurpinska-Winiarska (1996; hereafter DK96) to determine O−C values. We determined new periods by fitting the AAVSO observations along with the minima reported in this note. We used a least-squares linear regression weighted by the uncertainty of each observation. For the AAVSO data, we assumed the mean uncertainty ± 0.003 days.

T LMi

For T LMi (A0, R=12.95, $9^{\rm h}48^{\rm m}28\overset{\rm s}{.}54$, $+33^\circ17'20''$, J2000) we used the nearby Guide Star Catalog (GSC) star 2505.1038 $9^{\rm h}48^{\rm m}35\overset{\rm s}{.}4$, $+33^\circ13'06''$) and GSC 2504.252 ($9^{\rm h}47^{\rm m}53\overset{\rm s}{.}0$, $+33^\circ16'57''$) as the check and comparison star respectively. T LMi system was observed during the night of 15 February 1997 UT. We observed a primary minimum at HJD = 2,450,494.8857±0.0005 (Figure 1a). The O−C plot, using the AAVSO database, and a period P = 3.019846 days and JD0=2,446,910.332 (DK96) is shown in Figure 2a, along with the best-fit linear regression. The revised period is slightly shorter, P = 3.019841 ± 0.0000015 days.

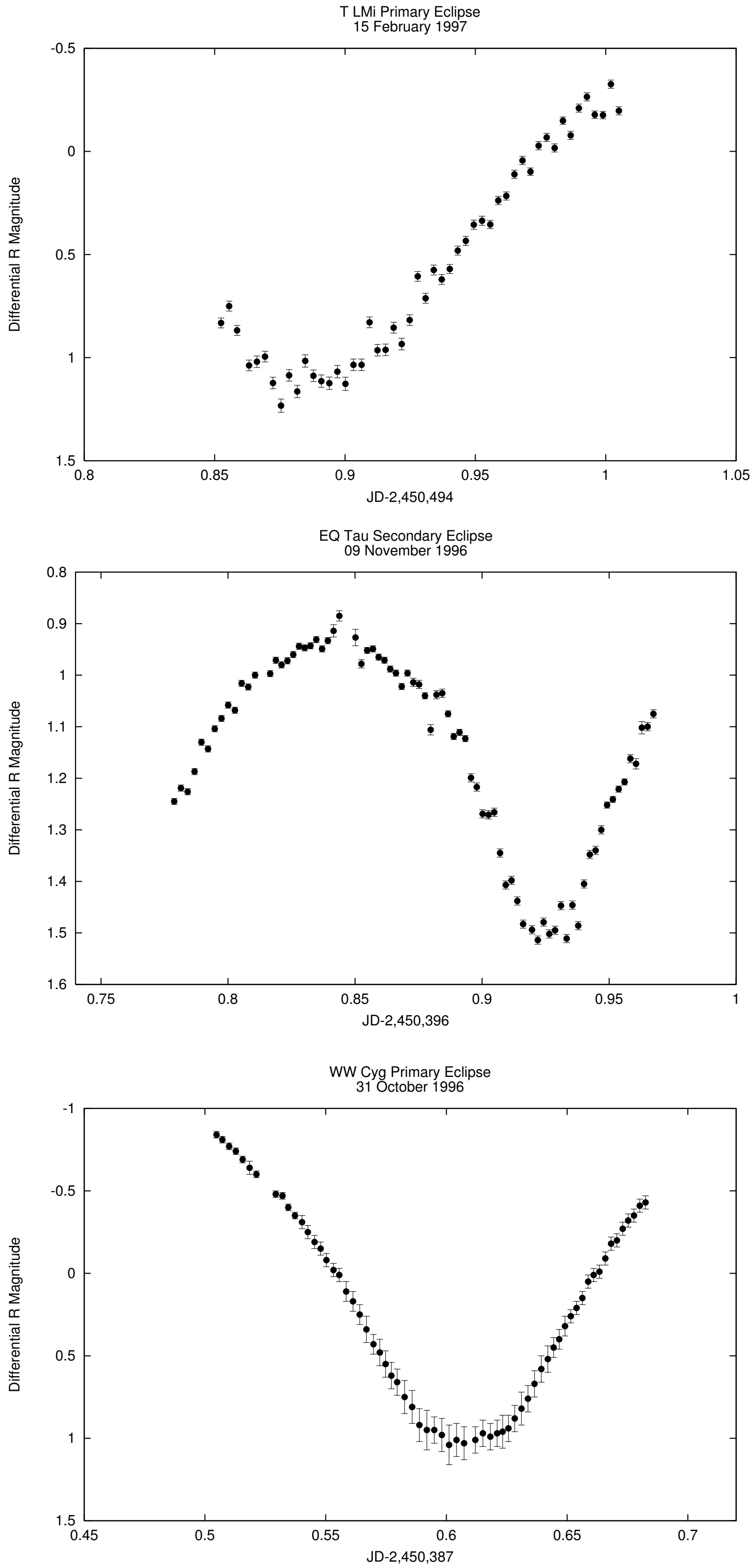

Figure 1. Light curves for T LMi (primary eclipse), EQ Tau (secondary eclipse), and WW Cyg (primary eclipse)

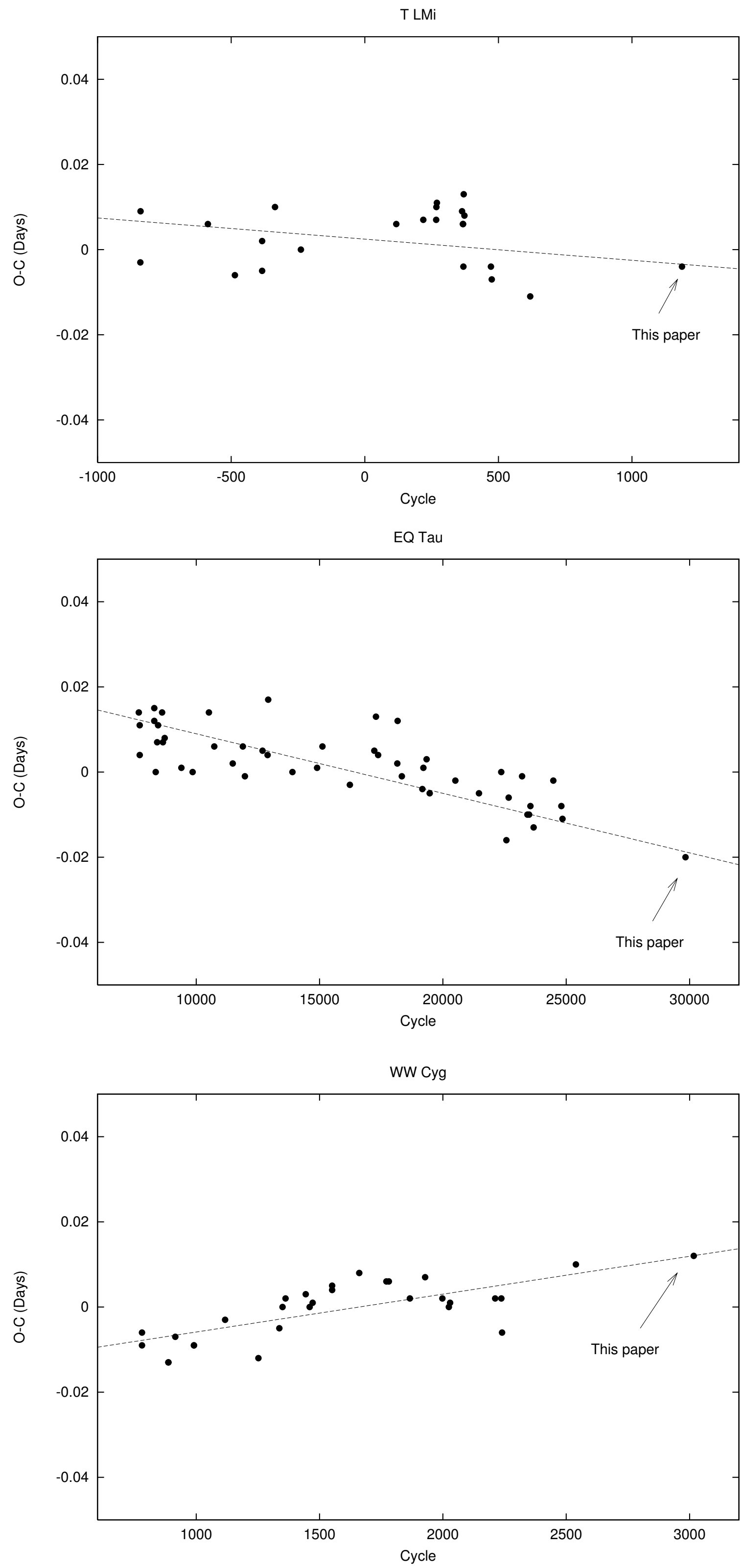

Figure 2. O−C plots for T LMi, EQ Tau, and WW Cyg. Historical data are from the AAVSO Archives (Observed Minima Timings of Eclipsing Binaries). The straight lines are weighted least-squares linear regressions

EQ Tau

For EQ Tau (G1, R=11.07, $3^h48^m13\overset{s}{.}38$, $+22°18'51\overset{''}{.}4$, J2000) we used the nearby star GSC 1260.642 ($3^h48^m42\overset{s}{.}9$, $+22°21'32''$) and GSC 1260.575 $3^h48^m16\overset{s}{.}4$, $+22°17'30\overset{''}{.}2$) as check and comparison star respectively. EQ Tau was observed during the night of 09 November 1996 UT. We observed a secondary minimum at HJD = 2,450,396.9250±0.0005 (Figure 1b). The O−C plot, using the AAVSO database, a period $P = 0.3413485$ days and $JD0 = 2,440,213.325$ (DK96), is shown in Figure 2b. The linear regression fit resulted in a slightly shorter period $P = 0.3413471 \pm 0.0000001$ days.

WW Cyg

For WW Cyg (B8V+, R=10.94, $20^h04^m02\overset{s}{.}69$, $+41°35'17''$, J2000) we used the nearby stars GSC 3158.220 ($20^h04^m25\overset{s}{.}2$, $+41°30'16''$) and GSC 3158.1498 $20^h04^m12\overset{s}{.}5$, $+41°33'06''$) as the check and comparison star respectively. We observed a primary minimum at HJD = 2,450,387.6074±0.0005 (Figure 1c). The O−C plot, using the AAVSO database, a period $P = 3.317769$ days and JD0=2,440,377.886 (DK96), is shown in Figure 2c. The linear regression fit resulted in a slightly longer period $P = 3.3177779 \pm 0.0000007$ days.

Table 1 summarizes the new ephemerides determined for all three systems.

Table 1. Revised Linear Ephemerides

Star	JD0	P(days)
T LMi	$2,450,494.8857 \pm 0.0005$	3.019841 ± 0.0000015
EQ Tau	$2,450,397.0957 \pm 0.0005$	0.3413471 ± 0.0000001
WW Cyg	$2,450,387.6074 \pm 0.0005$	3.3177779 ± 0.0000007

This research has been supported by the Iowa Space Grant Consortium and the National Science Foundation.

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PHOTOMETRY OF THE ECLIPSING BINARY 1RXSJ010124.9+411503

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In a continuing effort to identify X-ray sources discovered by the ROSAT satellite (Voges et al., 1996), optical photometric measurements of 1RXSJ010124.9+411503 = GSC 2807_1423 (Jenkner et al., 1990) were made. The data were observed with the automated 0.5m telescope and reduced in a fashion identical to that described in Robb et al. (1997).

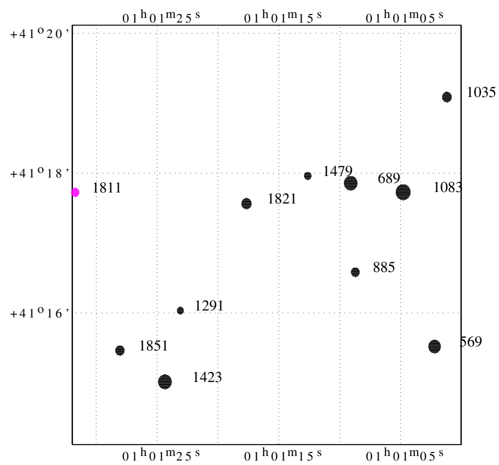

Figure 1. Finder chart of the field labeled with the GSC numbers (Jenkner et al., 1990)

In Figure 1 the field of stars is shown. Their designations, coordinates (J2000) and magnitudes from the Hubble Space Telescope Guide Star Catalog (GSC) (Jenkner et al., 1990) are tabulated in Table 1. Brightness variations during a night were measured by the standard deviation of the differential magnitudes, which ranged from $0\overset{m}{.}004$ for bright stars on a good night to $0\overset{m}{.}030$ for the faint stars on poor nights. Night to night variations were measured by a run mean of the five nightly averages, calculated and shown as ΔR in Table 1. The errors shown are the standard deviations, not the errors in the mean, and emphasize the high precision of this data. The ΔR differences in magnitude are calculated in the sense of the star minus GSC 2807_1083. Extinction effects were negligible due to the small field of view and no corrections have been made for them.

There is no ambiguity in the determination of the orbital period since three of the nights included more than half the light curve. Using the method of Kwee and van Woerden (1956), using data within $0\overset{d}{.}05$ of the minimum, three heliocentric Julian Times of primary

Table 1: Stars observed in the field of GSC 2807_1423

GSC No.	RA J2000.	Dec. J2000.	GSC Mag.	ΔR Mag.
2807_1851	$01^h01^m28^s$	$+41°15'28''$	13.0	$3.267 \pm .002$
2807_1423	$01^h01^m24^s$	$+41°15'01''$	10.8	$0.840 \pm .029$
2807_1083	$01^h01^m05^s$	$+41°17'44''$	10.2	-
2807_0689	$01^h01^m09^s$	$+41°17'51''$	10.9	$1.157 \pm .001$
2807_1821	$01^h01^m18^s$	$+41°17'34''$	12.6	$2.755 \pm .002$
2807_0885	$01^h01^m09^s$	$+41°16'35''$	13.3	$3.184 \pm .004$
2807_0569	$01^h01^m02^s$	$+41°15'31''$	11.4	$1.260 \pm .001$
2807_1035	$01^h01^m01^s$	$+41°19'05''$	12.8	$2.848 \pm .003$
2807_1811	$01^h01^m32^s$	$+41°17'43''$	13.6	$3.787 \pm .004$

minimum were found to be 2450785.8949(2), 2450787.9224(4), and 2450821.7243(3). A secondary minimum occurred at 2450784.8830(2). A fit to these times gives the ephemeris:

$$\text{HJD of Minima} = 2450784^{\text{d}}.5434(10) + 0^{\text{d}}.67601(8) \times \text{ E.}$$

where the uncertainties in the final digit are given in brackets.

The differential (GSC 2807_1423−GSC 2807_1083) R magnitudes phased at this period are plotted in Figure 2 with different symbols for each of the four December nights. The obvious asymmetry in the maxima, is indicative of starspots distributed asymmetrically over the surface of the star(s).

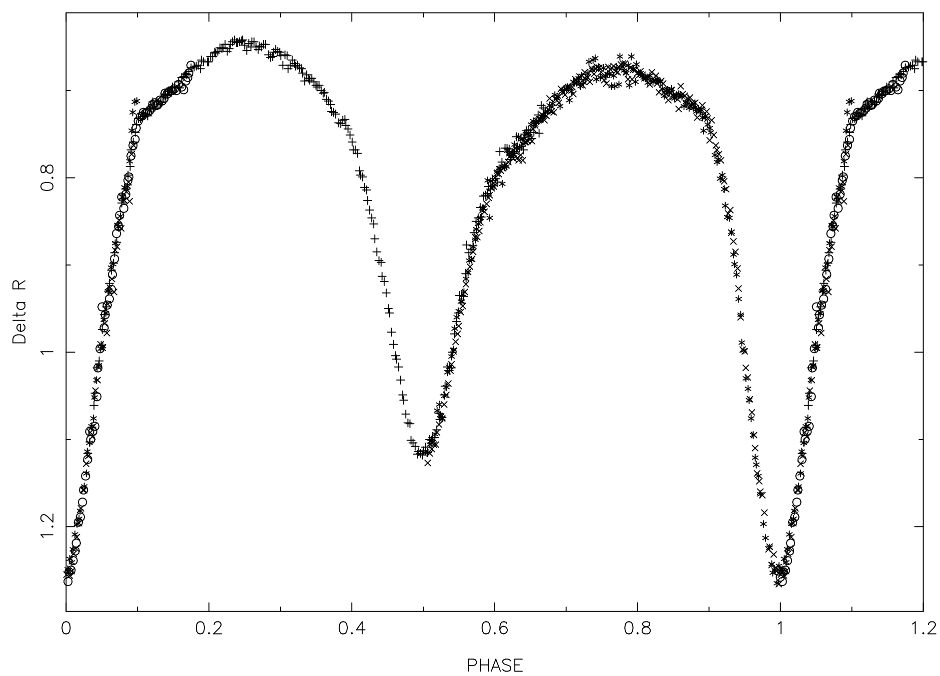

Figure 2. R band light curve of GSC 2807_1423 for 1997

To ascertain the temperature and brightness of the variable star, B and V frames of the field were obtained. Stars GSC 2807_1083 and GSC 2807_689 have B and V magnitudes (Urban 1998) measured by the Hipparcos satellite (ESA 1997). Relative to these stars,

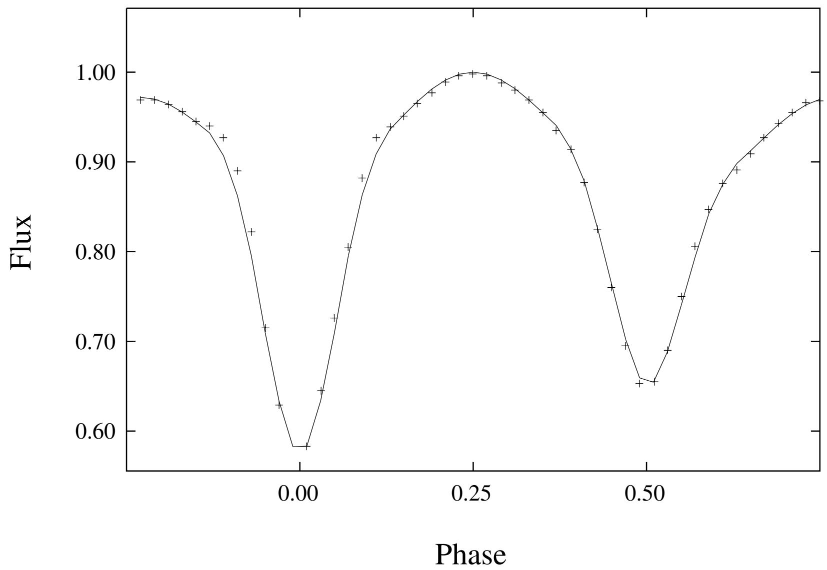

Figure 3. R band light curve (points) with example model (line) of the eclipsing system

measurements of GSC 2807_1423 give V=10.85 ± .03 and (B−V)=0.98 ± .02 at maximum light. Under rather poor photometric conditions with observations of only four nearby bright standard stars (Johnson et al., 1966), the colors of the variable star at maximum light were approximately $(V-R)_C = 0.5$, and $(R-I)_C = 0.4$. Great caution should be exercised in using these data since they are derived from only a few standard stars and the colors were transformed from the Johnson system to the Cousins system using the equations of Taylor (1986). These colors indicate that GSC 2807_1423 is a K1 spectral class star (Cousins 1981) and probably not a heavily reddened early type star.

From the shape of the light curve we can surmise that this is a detached system, which is nearly in contact. Using Binmaker 2.0 (Bradstreet 1993), an example model light curve was made, assuming the temperature of the large star to be 4750K. The data are best fitted with an inclination of 76.5°, a mass ratio of 0.84 and relative radii of 0.39 and 0.37. The temperature of the small star was adjusted to 4400K and a spot 14° in radius at a longitude of 230° was added to get the excellent fit seen in Figure 3. The mass ratio is not well determined but the uncertainty in the inclination is about ±2°. The relative radii, difference in temperature, and spot diameter are known to about ±5%.

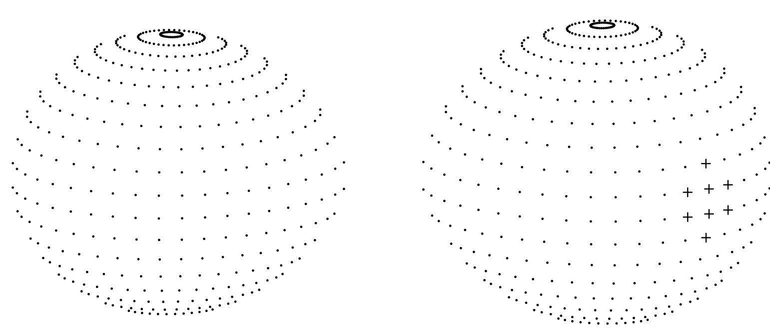

Figure 4. Three-dimensional model of the detached system at phase 0.75

The relative sizes and shapes of the components of the system and the spot are shown in Figure 4, again using Binmaker 2.0 (Bradstreet 1993).

The main-sequence system CG Cyg has a nearly identical period and spectral class yet it has much smaller relative radii of 0.24 and 0.22 (Popper 1994). To have such large relative radii GSC 2807_1423 must have either a smaller semi-major axis and therefore a smaller total mass or the stars are larger or some combination of these two parameters. Four scenarios which may explain the large size/small mass are: that the stars could be the end product of mass exchange; that they are two sub-giants approaching contact; that they are two stars contracting toward the main-sequence or that they have an unlikely distribution of spots mimicking distorted stars.

The star 1RXSJ010124.9+411503=GSC 2807_1423 is therefore a detached eclipsing system with late type components, at least one spot and an active corona or flares producing X-ray emission. Photometric observations are continuing to monitor light curve changes due to spot migration and period changes. Spectroscopic observations have been started to determine a spectral class for the system and to measure radial velocities to determine the masses and the scale of the system.

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UBV OBSERVATIONS OF AG Dra DURING THE 1996–1997 ACTIVE PHASE

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The symbiotic system AG Dra has undergone a great number of outbursts (Luthardt 1983, Skopal & Chochol 1994, Skopal 1994) and in many cases has displayed orbital photometric variability during the periods between them (Meinunger 1979, Hric et al. 1993). The last extended quiescent period was from 1987 to 1993 when the V magnitude of the system was about $9\overset{m}{.}8$. This period was followed by a new active phase which was characterized by two outbursts in 1994 and 1995 (Montagni et al. 1996). In the beginning of 1996 the brightness practically reached its typical values of the quiescent state, but soon after the star entered a phase of increased activity again. The maximum values of the brightness, observed by us during this phase, were in July 1996 (V = $9\overset{m}{.}25$) and June 1997 (V = $9\overset{m}{.}20$), followed by a rapid decrease almost to the quiescent magnitude.

Table 1. Photometric observations of AG Dra

JD−2450000	n	V	B	U	JD−2450000	n	V	B	U
267.3	3	9.24	10.12	9.15	477.7	2	9.76	11.04	11.00
268.3	3	9.26	10.14	9.21	478.7	2	9.75	11.06	10.99
293.6	2	9.48	10.46	9.73	504.6	3	9.72	11.01	10.96
294.6	3	9.43	10.37	9.60	520.5	3	9.78	11.07	10.95
295.4	3	9.41	10.35	9.47	628.5	3	9.17	9.99	8.96
296.4	3	9.38	10.32	9.45	629.4	3	9.21	10.05	9.05
297.3	3	9.41	10.31	9.42	643.5	2	9.14	10.00	8.92
303.4	2	9.34	10.27	9.36	651.3	2	9.26	10.10	9.11
317.3	3	9.48	10.50	9.47	652.3	2	9.25	10.08	9.07
321.3	3	9.58	10.68	9.83	698.3	3	9.28	10.18	9.19
322.3	3	9.60	10.68	9.84	699.3	4	9.32	10.18	9.25
324.3	2	9.60	10.69	9.85	701.3	3	9.30	10.17	9.20
390.2	2	9.77	11.05	11.08	702.3	3	9.28	10.17	9.19
391.2	3	9.74	11.02	11.10	704.3	2	9.32	10.21	9.22
398.2	3	9.69	10.98	11.06	729.2	3	9.64	10.70	10.17
431.2	2	9.72	11.04	11.14	739.2	5	9.65	10.78	10.46
466.3	2	9.72	11.01	—	741.2	2	9.71	10.83	10.60
476.7	2	9.75	11.05	11.00	742.2	3	9.69	10.83	10.58

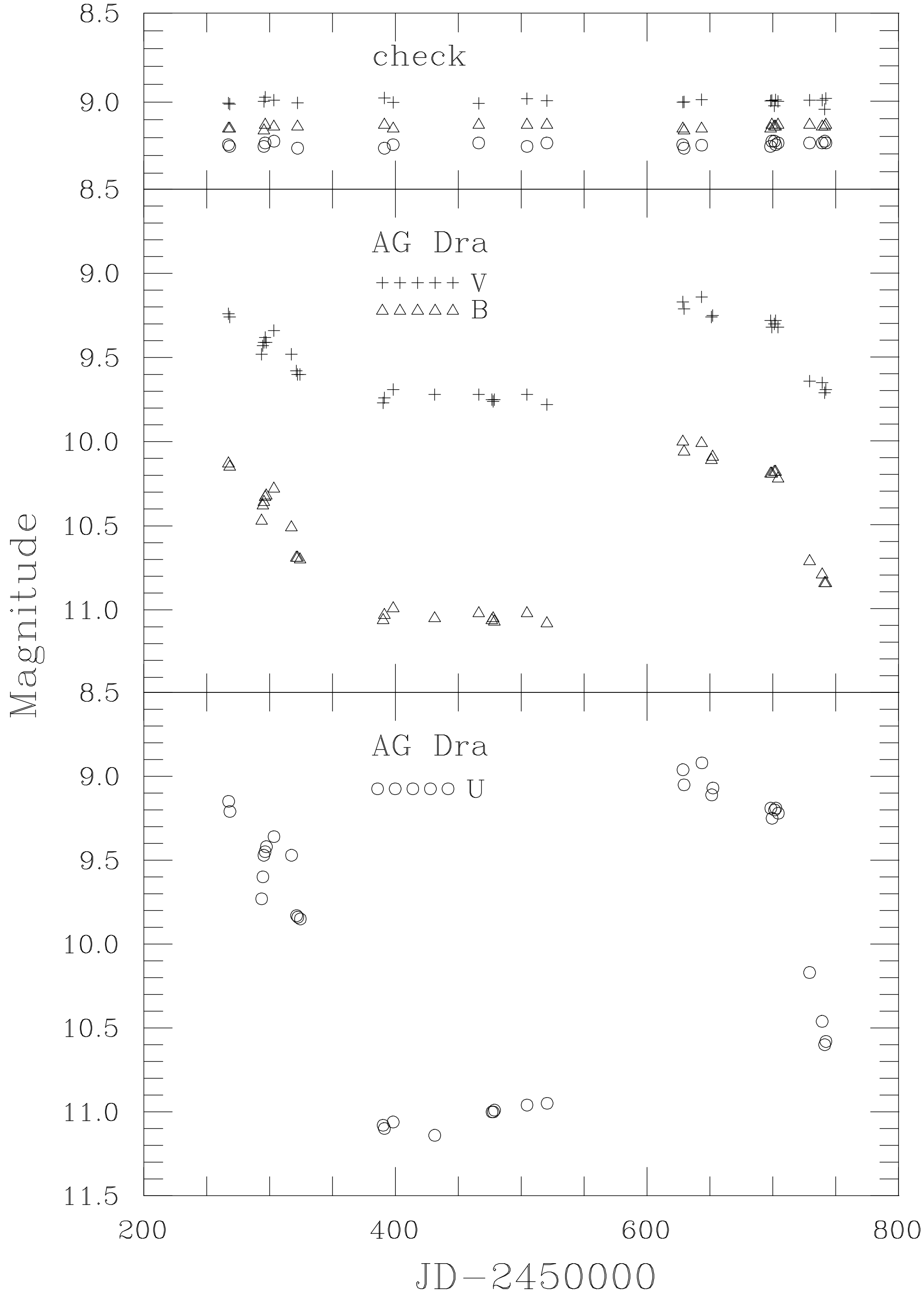

Figure 1. The UBV light curves of AG Dra

Our observations were performed in the UBV system during July 1996 – October 1997 (Table 1) with a single channel photoelectric photometer, mounted at the Cassegrain focus of the 0.6 m telescope of the National Astronomical Observatory "Rozhen". The brightness data in the period JD 2450317÷2450324 were obtained with the similar telescope and equipment of the Astronomical Observatory Belogradtchik. The star BD+67°925 having $V = 9\overset{m}{.}88$, $B - V = 0\overset{m}{.}56$ and $U - B = -0\overset{m}{.}04$ (Skopal & Chochol 1994) was used as a comparison star checked by the star BD+67°926. We estimated the accuracy using the observational data of the check star. The m.s. errors are not larger than $0\overset{m}{.}01$ in all bands.

The three colour light curve of AG Dra during the time of the observations is shown in Figure 1. Our data cover mainly the declining phases and the quiescent period between the two outbursts. It can be noted that the light monotonically increases in JD $\sim 2450290 \div 2450310$, although this interval is a part of the first declining phase. The brightness of AG Dra varied in all the colours, but the amplitude of these variations was largest in U and decreased with the wavelength. In the time between the outbursts it reached the typical values of the quiescent state. The variation in the U magnitude indicates a mean increase for the two light maxima by a factor of about 5.3 of the continuum flux compared with the quiescent period before the 1994 outburst. The B and V increase factors are equal to 2.3 and 1.6. In our view the reason for the visual brightening of AG Dra is the increased radiation of its nebula. This is directly seen from the energy distribution in the spectrum of AG Dra from IR to X-ray wavelengths, obtained during quiescence and outburst (see Fig. 5 of Greiner et al. 1997). The spectrum in the optical/near-UV region is dominated by a nebular continuum which strongly increases during the outburst phase. Therefore we conclude that the increase of the UBV fluxes results from an increase of the emission measure of the nebular component in the system. This is probably caused by a larger production of both the ionizing photons and the hot star wind, which developed during the outburst (cf. Viotti et al. 1994). Then we can determine the lower limit of the contribution of the nebula for the maximal values of the B and V light on the basis of the approach used in the work of Montagni et al. (1996), using the amplitudes of the variation. It turns out that this lower limit is about 55% in B and 35% in V.

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PHOTOELECTRIC MINIMA OF SELECTED ECLIPSING BINARIES AND MAXIMA OF PULSATING STARS

(BAV Mitteilungen No. 102)

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In this 35rd compilation of BAV results, photoelectric observations obtained in the years 1996 and 1997 are presented on 104 variable stars giving 150 minima and maxima. All moments of minima and maxima are heliocentric. The errors are tabulated in column "±". The values in column "O−C" are determined without incorporating nonlinear terms. The references are given in the section "remarks". All information about photometers and filters are specified in the column "Rem". The observations were made at private observatories. The photoelectric measurements and all the lightcurves with evaluations can be obtained from the office of the BAV for inspection.

Table 1. Eclipsing binaries

Variable		Min JD 24..	±	Ph	Obs	O−C			Rem
V699	Aql	50315.3981	.0010	L	FR	+0.0193	s	GCVS 85	5)
AP	Aur	50486.4297	.0005	LBV	AG	+0.0051	s	BAVM 67	2)
MP	Aur	50464.4604	.0010	L	FR	−0.2022		GCVS 85	5)
NSV2733	Aur	50446.2729	.0009	L	MS				1)
VW	Boo	50456.7071	.0004	L	MS	−0.0229		BAVR 2)	1)
FF	Cnc	50138.5328	.0010	L	FR	−0.0328	s	BAVM 65	1)
		50502.3866	.0010	L	FR	−0.0444	s	BAVM 65	5)
		50510.3204	.0010	L	FR	−0.0496	s	BAVM 65	5)
		50541.4162	.0010	L	FR	−0.0477		BAVM 65	5)
		50547.3671	.0010	L	FR	−0.0511	s	BAVM 65	5)
XZ	CMi	50515.3161	.0002	L	KI	−0.0053		GCVS 85	1)
AK	CMi	50489.4516	.0005	LBV	AG	−0.0123		GCVS 85	2)
		50516.3346	.0005	L	KI	+0.2736		GCVS 85	1)
V651	Cas	50489.3250	.0003	LBV	AG	+0.0020		BAVM 55	2)
WW	Cep	50412.3821	.0002	L	AG	+0.0005		BAVM 71	1)
AH	Cep	50464.3068	.0020	LBV	AG	−0.0328	s	GCVS 85	2)
CQ	Cep	50344.571 :	.001	LBV	AG	−0.070		GCVS 85	2)
TT	Cet	50446.2471	.0003	L	KI	−0.0336	s	GCVS 85	1)
TV	Cet	50470.2917	.0004	L	KI	+0.0084		GCVS 85	1)
TX	Cet	50450.3114	.0006	L	KI	+0.0208		GCVS 85	1)
VV	Cet	50441.2519	.0003	L	KI	+0.0860		GCVS 85	1)
NSV6177	Com	50520.4737	.0015	L	MS	+0.0129		BAVM 88	1)
		50540.4113	.0017	L	MS	+0.0126		BAVM 88	5)
CG	Cyg	50316.4416	.0002	LBV	AG	+0.0348	s	GCVS 85	2)
GO	Cyg	50397.399 :	.003	LBV	AG	+0.056		GCVS 85	2)
V478	Cyg	50343.396 :	.001	LBV	AG	+0.023		GCVS 85	2)

Table 1 (cont.)

Variable		Min JD 24..	±	Ph	Obs		O−C			Rem
V478	Cyg	50369.3181	.0009	LBV	AG		+0.0172		GCVS 85	2)
V680	Cyg	50360.4971	.0009	LBV	AG		+0.0163		BAVR 1)	2)
V828	Cyg	50370.3457	.0008	LBV	AG		−0.0439	s	GCVS 85	2)
V934	Cyg	50369.2723	.0010	L	FR		−0.0689	s	GCVS 85	5)
		50370.3289	.0010	L	FR		−0.0634		GCVS 85	5)
V934	Cyg	50371.3791	.0010	L	FR		−0.0643	s	GCVS 85	5)
		50390.2959	.0010	L	FR		−0.0663	s	GCVS 85	5)
		50391.3531	.0010	L	FR		−0.0602		GCVS 85	5)
		50392.4029	.0010	L	FR		−0.0614	s	GCVS 85	5)
V1004	Cyg	50402.2380	.0012	L	MS		−0.0982		GCVS 85	1)
		50428.2935	.0008	L	MS		−0.0993		GCVS 85	1)
YY	Del	50346.3760	.0002	L	KI		+0.0032		GCVS 85	1)
UX	Eri	50451.2875	.0004	L	KI		+0.0860		GCVS 85	1)
YY	Eri	50481.2888	.0002	L	KI		+0.0637		GCVS 85	1)
BL	Eri	50485.3256	.0005	L	KI		−0.0094		GCVS 85	1)
EN	Gem	50422.5289	.0010	L	FR		−0.0394		GCVS 85	5)
NSV7457	Her	50516.4872	.0005	L	MS					1)
		50541.4204	.0010	L	MS					1)
NSV7968	Her	50539.4455	.0024	L	MS					1)
WY	Hya	50465.4841	.0001	L	KI		+0.0148		GCVS 85	1)
AV	Hya	50540.3276	.0006	L	KI		−0.0436		GCVS 85	1)
DF	Hya	50481.4469	.0002	L	KI		−0.0614		GCVS 85	1)
NSV4539	Hya	49841.4072	.0017	LBV	AG		+0.0034		BAVM 96	2)
CO	Lac	50369.5259	.0004	LBV	AG		−0.0019		SAC 68	2)
UZ	Leo	50541.4396	.0007	L	KI		+0.1008		GCVS 85	1)
XY	Leo	50519.3375	.0004	LBV	AG		−0.0122	s	GCVS 85	2)
		50519.4807	.0004	LBV	AG		−0.0111		GCVS 85	2)
		50519.6212	.0004	LBV	AG		−0.0126	s	GCVS 85	2)
		50539.3671	.0002	L	KI		−0.0115		GCVS 85	1)
AL	Leo	50519.4784	.0005	LBV	AG		+0.0072	s	BAVM 53	2)
AP	Leo	50546.3526	.0003	L	KI		−0.0279		GCVS 85	1)
V404	Lyr	50346.4006	.0021	L	MS		−0.0675		GCVS 85	1)
		50379.2939	.0014	L	MS		−0.0667		GCVS 85	1)
NS	Mon	50481.4314	.0005	LBV	AG		+0.0017		BAVM 76	2)
V453	Mon	50444.4482	.0008	L	MS		−0.1236	s	GCVS 87	1)
		50508.3218	.0019	L	MS		+0.1433	s	GCVS 87	1)
		50519.3087	.0012	L	MS		−0.1488	s	GCVS 87	1)
		50530.2991	.0024	L	MS		−0.1508	s	GCVS 87	1)
V530	Mon	50442.5430	.0054	L	MS		+0.1003		GCVS 85	1)
		50443.5890	.0017	L	MS		+0.0953		GCVS 85	1)
		50446.4834	.0029	L	MS		+0.0992	s	GCVS 85	1)
V532	Mon	50439.5660	.0011	L	MS		+0.0807		GCVS 85	1)
		50462.4492	.0015	L	MS		+0.0817		GCVS 85	1)
NSV2980	Mon	50380.5737	.0007	L	MS					1)
		50464.4617	.0002	L	KI					1)
		50465.4964	.0010	L	MS					1)
DZ	Ori	50464.4577	.0011	L	MS		−0.2913		GCVS 85	1)
		50466.2910	.0020	L	MS		−0.2942		GCVS 85	1)
V343	Ori	50428.5065	.0007	LBV	AG		+0.1158		GCVS 85	2)
U	Peg	50368.3978	.0003	L	KI		−0.0646		GCVS 87	1)
		50402.3150	.0002	L	KI		−0.0651	s	GCVS 87	1)
BB	Peg	50359.4028	.0004	L	KI		+0.0058	s	GCVS 87	1)
DI	Peg	50376.3686	.0001	L	KI		−0.0103		GCVS 87	1)
IM	Per	50380.4335	.0008	L	MS		+0.0601		GCVS 87	1)
V482	Per	50380.3383	.0007	LBV	AG		+0.0495		BAVM 68	2)
Y	Sex	50548.3789	.0004	L	KI		+0.0277	s	BAVR 1)	1)
CU	Tau	49659.520 :	.0007	L	MS		+0.071	s	GCVS 87	1)
		50422.3284	.0002	L	AG		+0.0666		GCVS 87	1)
		50422.5384	.0003	L	AG		+0.0705	s	GCVS 87	1)
GR	Tau	50422.5188	.0007	LBV	AG		−0.0211		BAVR 3)	2)
NSV1651	Tau	50381.6571	.0037	L	MS					1)
NSV1651	Tau	50457.3057	.0031	L	MS					1)
		50465.3591	.0003	L	KI					1)
TY	UMa	50192.5278	.0010	L	FR	MS	−0.0583	s	GCVS 87	1)
		50193.5894	.0010	L	FR	MS	−0.0603	s	GCVS 87	1)

Table 1 (cont.)

Variable		Min JD 24..	±	Ph	Obs		O−C			Rem
TY	UMa	50194.4797	.0010	L	FR	MS	−0.0564		GCVS 87	1)
		50195.3651	.0010	L	FR	MS	−0.0573	s	GCVS 87	1)
		50195.5417	.0010	L	FR	MS	−0.0580		GCVS 87	1)
UY	UMa	50445.6650	.0010	L	MS		+0.0583		GCVS 87	1)

Table 2. RR Lyrae and Delta Scuti type stars

Variable		Max JD 24..	±	Ph	Obs	O−C		Rem
SW	Aqr	50361.3466	.0003	L	KI	−0.0019	GCVS 85	1)
CY	Aqr	50439.2230	.0001	L	KI	+0.0095	GCVS 85	1)
FY	Aqr	50315.5558	.0040	L	BK			4)
		50396.3642	.0040	L	BK			4)
AA	Aql	50336.3812	.0004	L	KI	+0.0002	BAVM 78	1)
RV	Ari	50462.2737	.0003	L	KI	−0.0025	GCVS 85	1)
RW	Ari	50464.3012	.0080	L	BK	−0.0952	GCVS 85	4)
UU	Boo	50509.4855	.0001	L	QU	+0.0953	GCVS 85	4)
CM	Boo	50539.5145	.0005	L	QU	−0.0431	BAVM 75	4)
		50547.4313	.0005	L	QU	−0.0433	BAVM 75	4)
AH	Cam	50518.4083	.0007	L	QU	+0.1364	GCVS 85	4)
SS	Cnc	50486.4554	.0005	L	QU	+0.0495	GCVS 85	4)
		50489.3907	.0005	L	QU	+0.0461	GCVS 85	4)
		50519.5128	.0005	L	QU	+0.0465	GCVS 85	4)
		50546.3289	.0005	L	QU	+0.0469	GCVS 85	4)
TT	Cnc	50520.3885	.0008	L	KI	+0.0763	GCVS 85	1)
VW	CVn	50502.6204	.0011	L	AG	+0.0946	BAVM 74	1)
		50519.6162	.0007	L	AG	+0.0912	BAVM 74	1)
X	CMi	50460.526	.004	L	PS	+0.005	BAVR 4)	3)
RV	CMi	50478.453	.004	L	PS	−0.179	GCVS 85	3)
AD	CMi	50517.3688	.0004	L	KI	+0.0053	GCVS 85	1)
AL	CMi	50391.617	.005	L	PS	−0.168	GCVS 85	3)
		50487.404	.005	L	PS	−0.168	GCVS 85	3)
		50488.498	.005	L	PS	−0.175	GCVS 85	3)
BB	CMi	50470.5080	.0012	L	KI	+0.0550	GCVS 85	1)
RR	Cet	50440.3014	.0005	L	KI	−0.0048	GCVS 85	1)
RZ	Cet	50456.2409	.0007	L	KI	−0.0558	GCVS 85	1)
S	Com	50540.377	.003	L	PS	+0.012	SAC 60	3)
RY	Com	50548.5550	.0040	L	BK			4)
DX	Del	50380.2962	.0006	L	KI			1)
RT	Equ	50391.334	.003	L	PS	−0.085	GCVS 85	3)
SZ	Gem	50515.3827	.0020	L	BK	−0.0336	GCVS 85	4)
KV	Gem	50463.5013	.0040	L	BK	−0.0386	GCVS 85	4)
SS	Leo	50541.4513	.0040	L	BK	−0.0063	GCVS 85	4)
ST	Leo	50550.4074	.0005	L	KI	−0.0094	GCVS 85	1)
SU	Leo	50515.407	.003	L	PS	−0.051	GCVS 85	3)
SW	Leo	50546.5513	.0010	L	FR			1)
AA	Leo	50539.4387	.0040	L	BK	−0.0438	GCVS 85	4)
AX	Leo	50540.4657	.0080	L	BK	−0.0322	GCVS 85	4)
BX	Leo	50554.4182	.0008	L	KI	−0.1289	GCVS 85	1)
RW	Lyn	50464.5241	.0020	L	BK	+0.0152	BAVM 75	4)
CM	Ori	50465.4799	.0020	L	BK	−0.0442	GCVS 85	4)
VV	Peg	50370.3425	.0004	L	KI	−0.0271	GCVS 87	1)
BH	Peg	50363.3647	.0007	L	KI	−0.0732	GCVS 87	1)
BP	Peg	50363.3307	.0040	L	BK	+0.0348	GCVS 87	4)
		50363.4432	.0040	L	BK	+0.0378	GCVS 87	4)
DH	Peg	50365.3689	.0011	L	KI	+0.0187	GCVS 87	1)

Table 2 (cont.)

Variable		Max JD 24..	±	Ph	Obs	O−C		Rem
KN	Per	50470.3274	.0040	L	BK	+0.1154	GCVS 87	4)
RY	Psc	50444.3339	.0005	L	KI	−0.2517	GCVS 87	1)
SS	Psc	50396.3352	.0006	L	KI	−0.0630	GCVS 87	1)
		50466.2812	.0080	L	BK	−0.0507	GCVS 87	4)
SY	Psc	50465.3427	.0040	L	BK	+0.0676	GCVS 87	4)
RV	Sex	50545.3884	.0008	L	KI			1)
SS	Tau	50439.3912	.0006	L	KI	−0.0892	GCVS 87	1)
UX	Tri	50446.2713	.0040	L	BK			4)

Remarks:

AG	Agerer, F.	Tiefenbach	MS	Moschner, W.	Lennestadt
BK	Birkner, C.	Hagen	PS	Paschke, A.	Rueti CH
FR	Frank, P.	Velden	QU	Quester, W.	Esslingen
KI	Kleikamp, W.	Marl			

:	= uncertain
s	= secondary minimum
L	= photoelectric observation - without filter
LBV	= as above - filter: B and V
1)	= photometer CCD 375x242 uncoated - without filter
2)	= photometer EMI 9781A - filter: V=GG495,1mm;B=BG12,1mm+GG385,2m
3)	= photometer Cryocam 89A - without filter
4)	= photometer ST-7 - without filter
5)	= photometer OES-LcCCD11 without filter
BAVM 53	= BAV Mitteilungen No. 53 = IBVS No. 3401
BAVM 55	= BAV Mitteilungen No. 55 = IBVS No. 3554
BAVM 65	= BAV Mitteilungen No. 65 = IBVS No. 3859
BAVM 67	= BAV Mitteilungen No. 67 = IBVS No. 3942
BAVM 71	= BAV Mitteilungen No. 71 = IBVS No. 4131
BAVM 74	= BAV Mitteilungen No. 74 = IBVS No. 4134
BAVM 76	= BAV Mitteilungen No. 76 = IBVS No. 4143
BAVM 88	= BAV Mitteilungen No. 88 = IBVS No. 4386
BAVM 96	= BAV Mitteilungen No. 96 = IBVS No. 4432
BAVM nn	= BAV Mitteilungen No. nn
BAVR 1)	= BAV Rundbrief 32, 36 ff
BAVR 2)	= BAV Rundbrief 32,122 ff
BAVR 3)	= BAV Rundbrief 35, 1 ff
BAVR 4)	= BAV Rundbrief 44,162 f
GCVS nn	= General Catalogue of Variable Stars, 4th ed. 1900+nn
SAC xx	= Rocznik Astronomiczny Nr. xx, Krakow (SAC)

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ON THE ORBITAL PERIOD CHANGES OF EG Cep

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EG Cep (BD +76°790, HD 194089, $V_{max} = 9.36$) was discovered by Strohmeier (1958) as an eclipsing binary with the orbital period of 0.5446 days. The shape of the light curve is typical of the β Lyr type with the minima depth 0.87 mag and 0.29 mag in V light.

EG Cep is a poorly observed binary. Its light curves were presented by Geyer (1961), Cochran (Wood, 1971), Van der Wal et al. (1972), Kaluzny & Semeniuk (1984) and Erdem et al. (1993). In the most comprehensive photometric study of EG Cep Kaluzny & Semeniuk (1984) determined the value of interstellar extinction as E(B−V) = 0.035 and the distance $d = 120$ pc. They used the intrinsic colour index $(B-V)_0 = 0.197$ to derive the spectral type A7 of the primary component, which is in disagreement with the spectral type A3 given in the HD catalogue. Etzel & Olson (1993) measured the half-width of the Mg 448.1 nm line and determined the projected rotational velocity of the primary component as $v_1 \sin i = 146$ km s^{-1}. Other spectroscopic observations of EG Cep are not available.

Photoelectric B and V light curves, analyzed by Kaluzny & Semeniuk (1984) with the Wilson & Devinney method, led to the mass ratio $q = (0.45 - 0.50)$ and a semi-detached configuration with the $M_1 \sim 1.8$ $M_\odot$ unevolved primary and evolved secondary component. Their analysis of the O−C diagram revealed a continuous orbital period increase. The quadratic term of 0.820×10^{-10} days was explained by a mass transfer rate $\dot{M} = 10^{-7}$ $M_\odot y^{-1}$ from the secondary to the primary component. Wolf & Diethelm (1992) determined the quadratic term as 0.782×10^{-10} days and noted that omitting the secondary minima, which are mentioned to be asymmetrical, two linear ephemeris are also suitable for explanation of the O−C diagram. Erdem et al. (1993) found the quadratic term to be 0.473×10^{-10} days.

The aim of this study is to present additional times of minimum light of EG Cep, improve its ephemeris formula and examine its orbital period changes.

The first set of our photoelectric observations of EG Cep was performed in 1983-84 using a multi-mode, nebular-stellar photometer attached to the 1.22 m Cassegrain reflector at the Kryonerion Astronomical Station (KAS) of the National Observatory of Athens, Greece. The B & V filters used are in close accordance to the standard UBV system. Estimated uncertainties of a single observation taken at the KAS were 0.008 mag and

Table 1. New times of minimum light of EG Cep.
The epochs were calculated using ephemeris (1)

Epoch	B		V		Obs.
	JD_{hel} 2 400 000+	σ [days]	JD_{hel} 2 400 000+	σ [days]	
34266	45591.44113	0.00003	45591.43957	0.00010	KAS
34268	45592.52767	0.00003	45592.52856	0.00034	KAS
34269.5	45593.34637	0.00014	45593.34689	0.00017	KAS
34914	45944.35676	0.00024	45944.35516	0.00028	KAS
34916	45945.44566	0.00012	45945.44395	0.00006	KAS
34919.5	45947.35141	0.00022	45947.34913	0.00010	KAS
43588	50668.41219	0.00021	50668.41180	0.00017	SL
43599	50674.40330	0.00028	50674.40337	0.00034	SP
43714.5	50737.31060	0.00060	50737.31000	0.00040	SL
43744	50753.37367	0.00039	50753.37436	0.00017	SL
43794	50780.60460	0.00070	50780.60473	0.00030	SP

0.010 mag in B and V passbands, respectively. The stars BD +75°737 (V = 9.5, sp. type A0) and BD +74°857 (V = 10.7, sp. type A2) served as a comparison and check star, respectively. The second set of EG Cep observations was obtained in 1997 at the Skalnaté Pleso (SP) and Stará Lesná (SL) observatories of the Astronomical Institute of the Slovak Academy of Sciences. In both cases 0.6 m Cassegrain telescope equipped with a single-channel pulse-counting photoelectric photometer was used. The accuracy of the SP and SL observations taken in B and V passbands was two times higher in comparison with the KAS data. The stars BD +76°791 (V = 9.2, sp. type K2) and BD +76°789 (V = 9.6, sp. type A0) served as a comparison and check star, respectively. Data reduction, atmospheric extinction correction and the transformation to the standard international system were carried out by usual way.

Our observations led to the determination of 11 new times of minimum light. We have calculated the times of minima separately from B and V observations using Kwee & van Woerden's (1956) method (Table 1).

In order to investigate the real period variations of EG Cep, we have collected all available times of minima from the literature and added our 11 times of minima (BV averages). Complete list of minima times is given in the paper by Chochol et al. (1998). They were used to construct the O−C diagram (Figure 1) applying the following ephemeris:

$$Min\ I = 2426929.4376 + 0.5446216 \times E. \tag{1}$$

To minimize the large scatter appearing in the observational material, mean values were calculated for all kinds of the observational data. Then, the period changes seen in the O−C diagram (Figure 1) are examined using the *classical* parabola as well as the new method proposed by Kalimeris et al. (1994).

a) In the first case, we get the following improvement of the ephemeris:

$$\text{Min I} = \text{JD}_{\text{hel}}\ \underset{\pm 12}{2\,426\,929.4575} + \underset{\pm 10}{0.54461943} \times E \ \underset{\pm 19}{+4.51} \times 10^{-11} \times E^2. \tag{2}$$

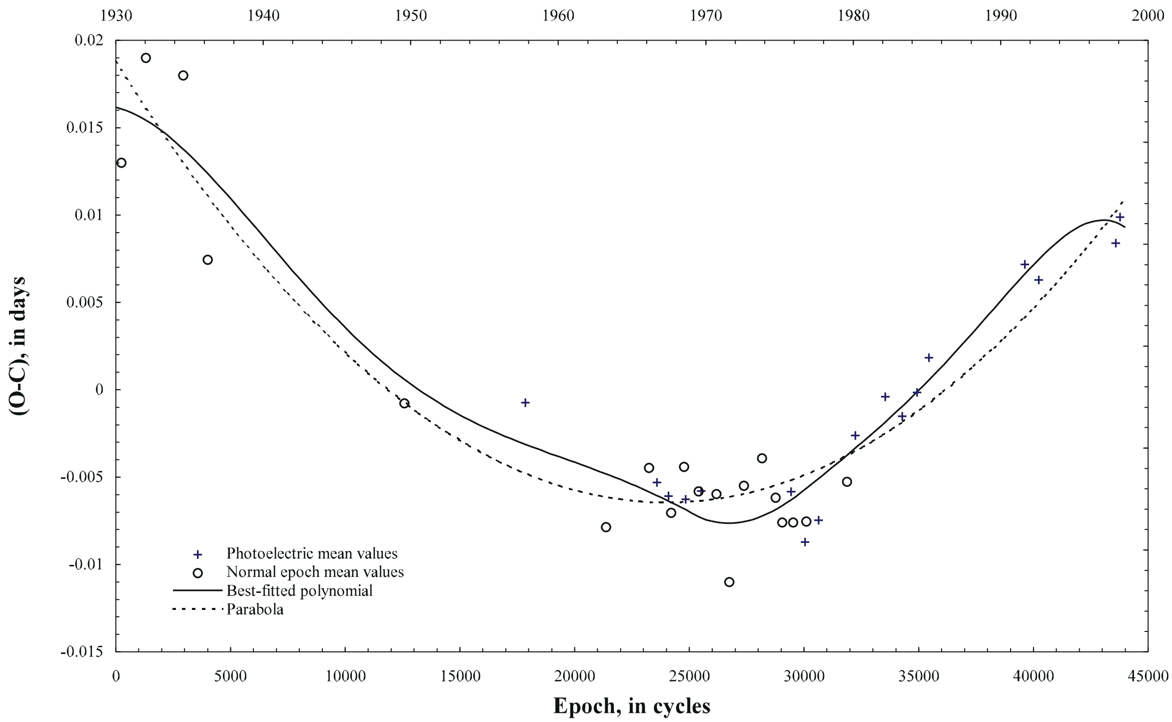

Figure 1. The O–C diagram of EG Cep

The larger value of the quadratic term in the parabolic ephemeris given by Kaluzny & Semeniuk (1984) and Wolf & Diethelm (1992), in comparison with the value published by Erdem et al. (1993) and our ephemeris (1), was caused by the fact that the first two authors omitted Strohmeier's (1958) observations.

b) Using Kalimeris et al. (1994) method, we described the O–C diagram of EG Cep piecewise (Figure 1), using two fourth-order polynomials and connecting their parts (descending and ascending branch) using a spline interpolant (Kalimeris et al., 1995). Then, it is easy to find the way the real orbital period P(E) of the system behaves. In Fig. 2, one can see the variation of the real period P(E) of EG Cep for the last 70 years. It is obvious from Figure 2 that a period jump of the order of $\Delta P = 2.023 \times 10^{-6}$ days occurred at E=27200 cycles corresponding to the year 1972.

The use of the *classical* parabola leads to a continuous increase of the period of EG Cep. On the other hand, one could use two linear fittings for the descending and ascending branches of the O–C diagram of the system and see that a sudden period increase occurred around the year 1972 (Chochol et al., 1998). The answer to what really happens is given using Kalimeris et al.'s (1994) method, as was applied here. Comparing the fittings of the O–C diagram of EG Cep we get from the parabola and from the piecewise description, the great gain is not immediately seen. This comes from the calculation of the real period P(E). Indeed, Kalimeris et al. (1994) method permits us to compute it in a simple and accurate mathematical way. Moreover, the jump in P(E), presented in Figure 2, does not only give the answer (i.e. that really a sudden period change has occurred), but we can also find when this has happened and how large it was. Finally, from a simple linear fitting –after period's jumping– we get the following linear ephemeris:

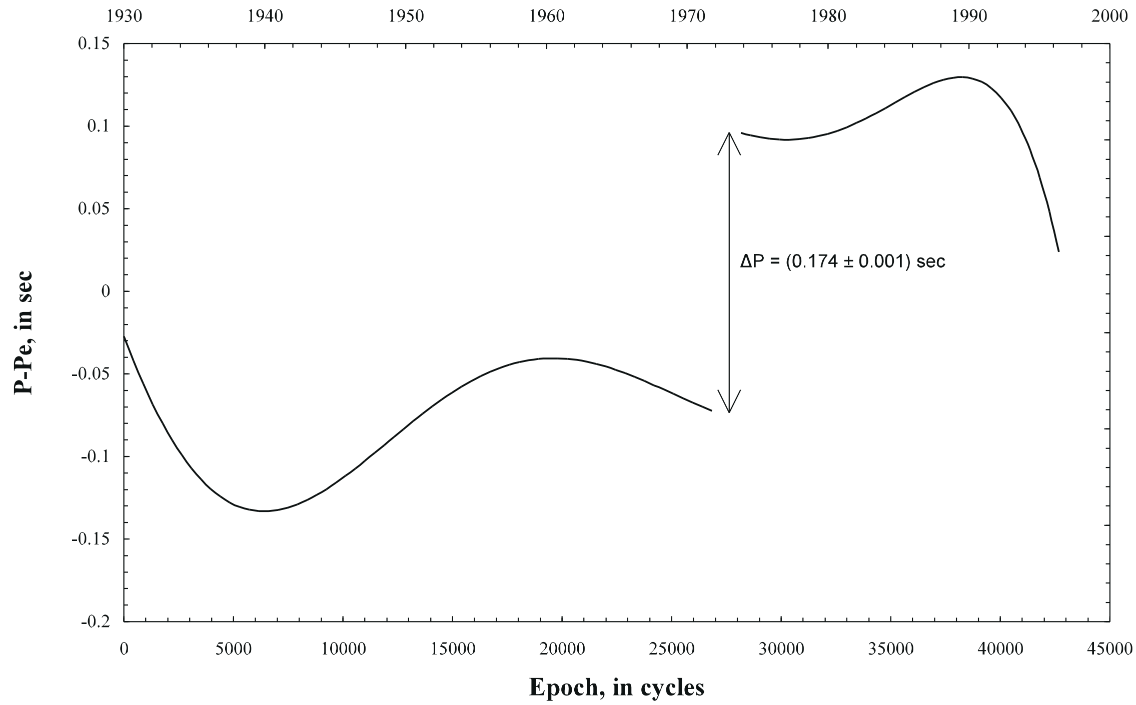

Figure 2. The real period variation of EG Cep

$$\begin{array}{lll} \text{Min I} = \text{JD}_{\text{hel}}\ 2\,426\,929.3987 & +\ 0.54462272 & \times E. \\ \qquad\qquad\qquad\qquad \pm 20 & \qquad\quad \pm 6 & \end{array} \qquad (3)$$

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THE RADIAL VELOCITY OF THE roAp STAR γ Equ

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The sharp-line cool magnetic SrCrEu star γ Equ (HD 201601) is a very slowly rotating star (P $\simeq$ 74 years, Leroy et al., 1994) and is well known as a roAp star with at least four excited unstable modes (Martinez et al., 1996). The radial velocities obtained during the history of investigations of this star did not show any long-term variations larger than the observational errors. Recently, Scholz et al. (1997) published their results of radial velocity measurements of γ Equ made in 1995 and 1996. Nine of their radial velocities show a rapid increase from a mean value of -16.81 km s^{-1} up to a maximum at -4.28 km s^{-1} within the interval JD 2449608 - JD 2450356, while two later measurements (on JD 2450391 and JD 2450410) show a decreasing V_r which seems to converge towards previous values. They suggested that γ Equ is a long-period binary star with a high eccentricity.

The results of Scholz et al. (1997, hereafter S97) disagree with our 758 homogeneous radial velocity estimations for γ Equ collected using a cross-correlation technique, during 27 nights in 1994, 1995 and 1996. The epochs of our measurements encompass the phase of the magnetic minimum and many of the nights on which S97 observed, including a most critical one.

The main part of our observations were carried out within a collaboration between Odessa Observatory (Ukraine) and Institute of Astronomy, Russian Academy Sciences (Russia) on radial velocity investigations of selected chemically peculiar stars (Mkrtichian et al. 1997). We have used the 1.0m and 0.6m telescopes of Simeiz Observatory (Mt. Koshka, Crimea, Ukraine) and the 0.7m telescope of Sternberg Institute (Moscow, Russia) equipped with the transportable CORAVEL-type scanner (hereafter RVS), (Tokovinin 1987). Brief reports on rapid photometric and radial-velocity variations of the roAp star γ Equ will be given in two papers by Mkrtichian (1998) and Mkrtichian et al. (1998), while the present publication is devoted to the long-term behaviour of the radial velocity of γ Equ. Two radial velocity measurements – one of which at a most critical date – were also acquired at Observatoire de Haute-Provence (CNRS, France), using the 1.0m Swiss telescope equipped with the CORAVEL scanner (Baranne et al. 1979), as part of a programme of search for binaries among cool Ap stars.

The observational procedure on RVS and CORAVEL scanners includes blocks of measurements of the star, immediately preceded and followed by a velocity calibration exposure using an internal Ne discharge lamp (RVS) or a Fe hollow cathode lamp (CORAVEL). During every night, several measurements of radial-velocity standard stars were used for correction of low amplitude instrumental drifts.

In Table 1, the journal of radial velocity observations is presented.

Table 1. The journal of 1994 - 1996 radial velocity observations of γ Equ.

$HJD_{start} - HJD_{end}$	Mean V_r $\mathrm{km\,s^{-1}}$	Error $\pm\mathrm{km\,s^{-1}}$	N	Tel. m	Observatory	Observer(s)
2449530.536 - .556	−17.00	0.144	17	1.0	SO	RAS
2449556.540 - .549	−16.03	0.302	8	1.0	SO	SNN
2449569.424 - .437	−17.13	0.094	8	0.6	SO	SNN&GNA
2449607.393 - .407	−16.61	0.289	11	0.6	SO	SMG&SME
2449608.300 - .351	−17.08	0.216	24	0.6	SO	SMG&SME
2449609.425 - .439	−17.38	0.220	11	0.6	SO	SMG&SME
2449636.170 - .259	−15.350	0.131	44	0.7	SAI	SNN
2449648.195 - .284	−19.816	0.068	49	0.7	SAI	SNN
2450042.261	−16.86	0.46	1	1.0	HP	MJC
2450254.5347 - .5416	−16.91	0.135	11	1.0	SO	RAS
2450255.5216 - .5355	−16.40	0.149	19	1.0	SO	RAS
2450256.5265 - .5397	−16.39	0.285	18	1.0	SO	RAS
2450257.5273 - .5432	−16.74	0.224	22	1.0	SO	RAS
2450258.5280 - .5405	−16.70	0.179	17	1.0	SO	RAS
2450264.5472 - .5604	−17.05	0.145	18	0.6	SO	RAS
2450265.5479 - .5618	−17.07	0.110	19	0.6	SO	RAS
2450267.5501 - .5647	−16.83	0.303	18	1.0	SO	GEV
2450268.558 - .567	−16.97	0.293	13	1.0	SO	GEV
2450269.551 - .559	−16.97	0.246	11	1.0	SO	GEV
2450270.549 - .556	−16.64	0.308	10	1.0	SO	GEV
2450271.554 - .559	−16.17	0.463	8	1.0	SO	GEV
2450272.5592 - .5636	−16.89	0.304	10	1.0	SO	GEV
2450285.4864 - .4954	−18.15	0.168	11	0.6	SO	SME
2450316.4801 - .5783	−16.69	0.054	115	0.6	SO	AS&MDE
2450319.3284 - .4489	−16.60	0.049	126	0.6	SO	AS&MDE
2450321.3158 - .4652	−16.86	0.055	137	0.6	SO	AS&MDE
2450355.384	−16.77	0.45	1	1.0	HP	vES

Observatory:
SO - Simeiz Obs., SAI - Sternberg Astron. Inst., HP - Haute-Provence Observatory.
Observer(s):
ASV — S.V. Antipin, GEV — E.V. Glushkova, GNA — N.A. Gorynya, MDE — D.E. Mkrtichian, MJC — J.-C. Mermilliod, RAS — A.S. Rastorgouev, SNN — N.N. Samus, SME — M.E. Sachkov, SMG — M.G. Smekhov, vES — S. van Eck.

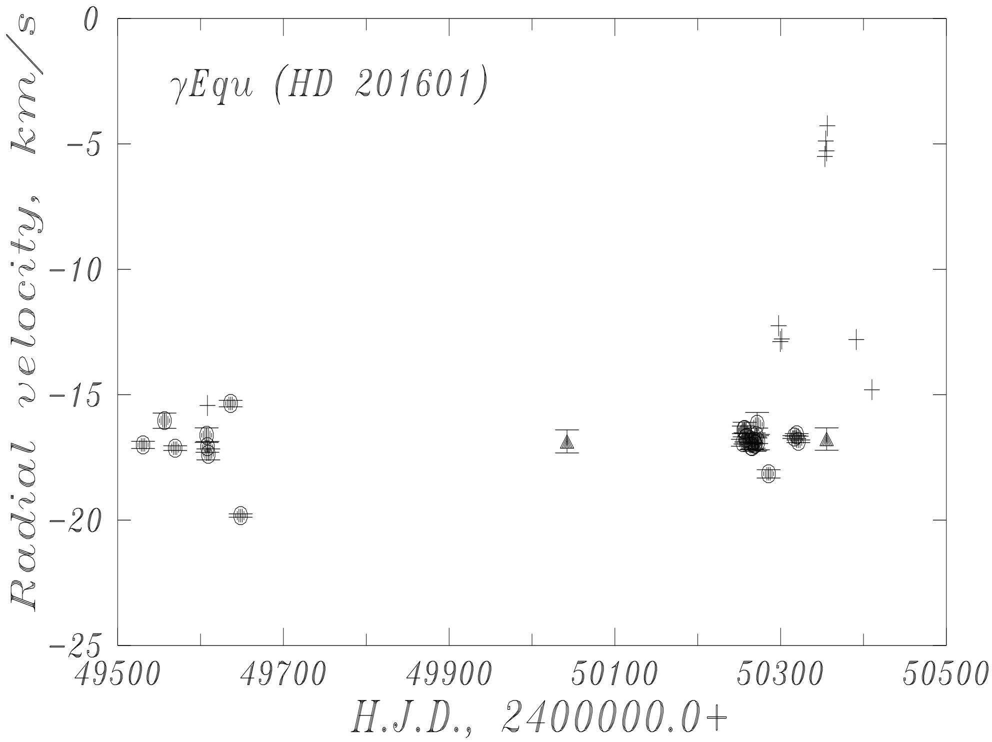

Figure 1. The 1994-1996 radial velocities of γ Equ: full dots — RVS data, triangles — CORAVEL data, crosses — Scholz et al. (1997) data

Figure 1 shows the mean radial velocities of γ Equ versus the Julian Date in 1994–1996, obtained with RVS (full dots), CORAVEL (triangles), and by S97 (crosses). As can be seen, our numerous cross-correlation radial velocities (758 estimations) cover the 1994–1996 interval, but do not show any drastic increase during the year 1996, contrary to what S97 reported. For instance, our radial velocity estimate of -16.77 at the epoch HJD 2450355.384 was obtained just one hour before the measurement yielding $Vr = -5.28\ \mathrm{km\,s^{-1}}$ according to S97 (at HJD 2450355.426), which makes a difference as large as $-11.49\ \mathrm{km\,s^{-1}}$. Whereas our results are in full agreement, not only with our own previous values, but also with all radial velocities published in the literature, those published by S97 are clearly discrepant. Our data show that the radial velocity of γ Equ has remained constant within the errors on long timescales at a value which, during the 1994-1996 interval, amounted to $-16.83 \pm 0.038\ \mathrm{km\,s^{-1}}$.

We can summarize the results of our note as follows:

- We obtained 758 new, homogeneous and precise radial velocities of γ Equ in 1994–1996 using cross-correlation scanners.
- The mean radial velocities for individual nights of 1994–1996 are constant on long timescales within the errors and average to $-16.83 \pm 0.038\ \mathrm{km\,s^{-1}}$. This value is close to the average radial velocity for the last 70 years.
- Our numerous radial-velocity measurements of γ Equ, the epochs of which largely overlap those of S97, do not show any significant increase of radial velocity at the time of the year 1996 when such a change occurred according to S97. We conclude that there is as yet no evidence for a binary companion to γ Equ.

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NEW PERIODS FOR VARIABLE STARS IN CYGNUS

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This work summarizes the results of photographic photometry obtained over 24 years at the Skalnaté Pleso (1979-1993) and Asiago (1969-1988) observatories. The periods of light variation, the epochs of the maxima or of the minima, the types of variability for 17 variable stars are presented.

A total of ninety photographic plates of 9x12 cm and 24x24 cm formats with emulsions ORWO ZU-2 and ORWO ZU-21 was obtained using the 30/150 cm astrograph of the Skalnaté Pleso Observatory. The limiting magnitude of the observational material is about 16.5 m_{pg}. The resulting photographic magnitude is close to the photoelectric B one. At the Asiago Observatory 85 photographic plates were taken using the Schmidt telescope (67/92/215 cm). On the basis of this material Margoni and Stagni (1984) and Margoni *et al.* (1989) found 99 new variable stars. Thanks to Professor Margoni (1993), who has provided us with his original material in the reduced form, we were able to extend our observational material and to double the time interval investigated by us. During the complex survey of the combined observational material, we have identified and selected 17 variable stars for next investigation. Stars from the close neighbourhood of V1329 Cygni whose magnitudes were measured by L. Kohoutek were used as comparisons, as well as those used as comparisons by Margoni, 18 objects in total.

On the basis of the measurements obtained by iris microphotometer we have constructed the sensitometric characteristic for each plate, with the help of which the photographic magnitudes of the individual stars studied were determined. Moreover, the heliocentric correction was applied to all the JD of the exposures. Our main aim was to determine new periods or improve the accuracy of the periods already known for all the variable stars studied. With this purpose in mind, we have performed a period analysis of all the data, using the method of Fourier analysis (Deeming 1975, Kurtz 1985), the phase dispersion minimization method (Stellingwerf 1978) and the method of Fourier harmonic analysis (Andronov 1995) which fits the first harmonic term of trigonometric polynomial to the observed data. The advantage of the last method is the fact that it provides one not only with the determination of the parameters of variability alone, but also with the determination of the corresponding errors. Further result of the analysis is determination of the moments of maxima (eventually minima) of the light changes through the routine by R. Komžík (1995), making use of the following methods: the parabola fit, the polynomial fit, the "center of mass", Kwee and Van Woerden, the sliding integrations and the tracing paper polygonal line. The averages of values obtained through the individual methods were considered as the resulting values. The moments of maxima and minima are determined at about the mid-time of the observational interval. The type of the variability was determined as the last parameter, on the basis of the length of the period, the amplitude of light changes, the shape of light curve and with the help of the characteristics defined in the GCVS.

All the results obtained through the analysis of seventeen variable stars which have been objects of our study are well-arranged described in Table 1.

Table 1: The resulting parameters for variable stars studied

GCVS/IBVS	MS	$\alpha_{1950.0}$	$\delta_{1950.0}$	Δm_{pg}	P [d]	T_{max} (JDhel.)	Type	Note
V375 Cyg		20 45 32	+35 42.1	11.9 - 14.6	335.9	2447395.0	SRA	1
V384 Cyg		20 44 39	+34 48.6	12.1 - 17.5	114.8-117.3	-	M	2
V523 Cyg		21 00 04	+35 06.9	11.6 - 18.0	379.4	2444458.4	M	3
V1838 Cyg	18	20 43 45	+36 33.2	12.0 - 18.0	340.7	2443967.7	M	3
V1854 Cyg	38	20 46 17	+36 41.5	13.4 - 15.5	106.5	2446240.0	SR	4
V1856 Cyg	40	20 46 21	+35 16.1	13.0 - 15.7	1.999201	2448785.201	EA	3, 5
V1863 Cyg	51	20 47 42	+37 02.6	13.3 - 15.5	7.322	2446499.7	CEP	4, 6
V1864 Cyg	53	20 48 09	+37 18.9	14.3 - 18.0	463.2	2443494.3	M	3
V1868 Cyg	63	20 49 17	+36 42.5	13.5 - 18.5	402.6	2443548.8	M	3
V1871 Cyg	66	20 49 42	+35 05.9	12.5 - 15.6	692.5	2444262.0	M:	3, 6
V1877 Cyg	73	20 50 42	+34 12.3	13.1 - 15.2	4.54091	2444183.904	CEP	4, 7
V1886 Cyg	83	20 54 16	+36 10.3	13.4 - 15.6	254.8	2446140.0	SR	4, 7
V1889 Cyg	86	20 55 09	+33 56.5	13.4 - 15.8	1.3311	2446092.26	CEP	6, 8
V1894 Cyg	95	20 58 43	+33 53.3	12.1 - 13.4	257.8	2443749.0	M:	6, 8
-	8	20 41 03	+35 19.3	12.1 - 13.7	0.2534	2446599.129	RR Lyr	4, 7
-	91	20 57 29	+36 26.6	12.4 - 15.4	0.345372	2447415.787	RR Lyr	4, 7
-	99	21 03 03	+35 28.1	13.9 - 16.7	-	-	SR	9

Notes to table 1

1. the value of the period is close to the originally published one (Margoni *et al.*, 1989)
2. the value of the period is changing in the interval indicated with a period of 16.3 years
3. accuracy of the value of the period has been improved
4. value of the period has been determined for the first time
5. epoch of minimum is presented
6. the original classification was not confirmed, a new type of variability was determined
7. type of variability has been determined for the first time
8. the originally determined value of the period was not confirmed, a new value of the period was determined
9. no unambiguous period could be determined

For all the variable stars studied (except of V384 Cyg and MS99, with respect to the character of their variability and the results found), new, more accurate values of the epoch of the extremum were determined

Table 1 summarizes the result of our study. The first two columns give the final designation according to the GCVS and IBVS (Kholopov *et al.*, 1987) or the preliminary designation given by Margoni and Stagni (1984). We also present equatorial coordinates for the equinox 1950.0 for each star, which is compatible with the GCVS. The parameters of variability of these stars are further presented there: the interval of light changes, the value of period, the epoch of maximum (or minimum for the eclipsing binary) and the type of variability. The note characterizes more closely the parameters obtained for the individual variable stars investigated by us or describes the relation of the results achieved by us to the results presented in the literature (GCVS, Margoni and Stagni 1984 and Margoni *et al.* 1989).

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HD 84800: A NEW δ SCUTI VARIABLE

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We present photometric data for HD 84800 establishing δ Scuti type variability for this star. Furthermore we solve the previous discrepancy of different spectral classifications (A4 V or A2 II) in the literature by using the Hipparcos parallax. As a result of the analysis the found periodicity is likely to be a high overtone f-mode.

HD 84800 (HIP 48129, V = 7.79) was originally used as one of the comparison stars for HD 84123 (HIP 47792, λ Boo spectral type, V = 6.81) during a photometric survey of pulsating λ Bootis stars (Paunzen et al. 1998). Our program star HD 84123 as well as the second comparison star HD 84388 (HIP 47934, F2 spectral type, V = 7.10) turned out to be constant.

Photometric observations were performed with one of the University of Vienna automatic photometric telescopes (APT) in the night of 06/07.02.1997 with an integration time of 30 seconds. For a detailed description of the APT see Strassmeier et al. (1997). Figure 1 shows the differential light curves for all three stars in Strömgren *b*. A preliminary Fourier analysis of these data results in a frequency of 42 d^{-1} (= 486 μHz), P = 34 min and a peak-to-peak amplitude of 6.3 mmag (Figure 2).

Using the Hipparcos parallax $\pi = 6.66 \pm 0.95$ mas, and assuming $E(B-V) = 0$ (Bartkevičius et al. 1992) we estimate an absolute magnitude $M_{\rm V} = +1.91 \pm 0.32$ mag for HD 84800. This result confirms the spectral type A4 V (Bartkevičius et al. 1992) and rejects the A2 II classification by Bartaya (1979). Note that for an A2 II star the corresponding M_v is about -3 mag.

In order to estimate a Q-value for the detected pulsation, typical astrophysical quantities for an A4 V star were adopted from Schmidt-Kaler (1982) since neither Strömgren nor Geneva photometry is available: $\log g = 4.3$, $T_{\rm eff} = 8500$ K and $B.C. = -0.16$ mag. These parameters give a Q-value of 0.015 days based on López de Coca et al. (1990):

$$log\,Q = -6.456 + log\,T_{\rm eff} + 0.5\,log\,g + 0.1\,M_{\rm bol} + log\,P$$

A comparison with theoretical Q-values listed in Stellingwerf (1979) results in the exclusion of the fundamental and the first overtone mode for the detected variability. However, this conclusion remains preliminary since "tabulated" values for a "standard" A4 V-type star have been used.

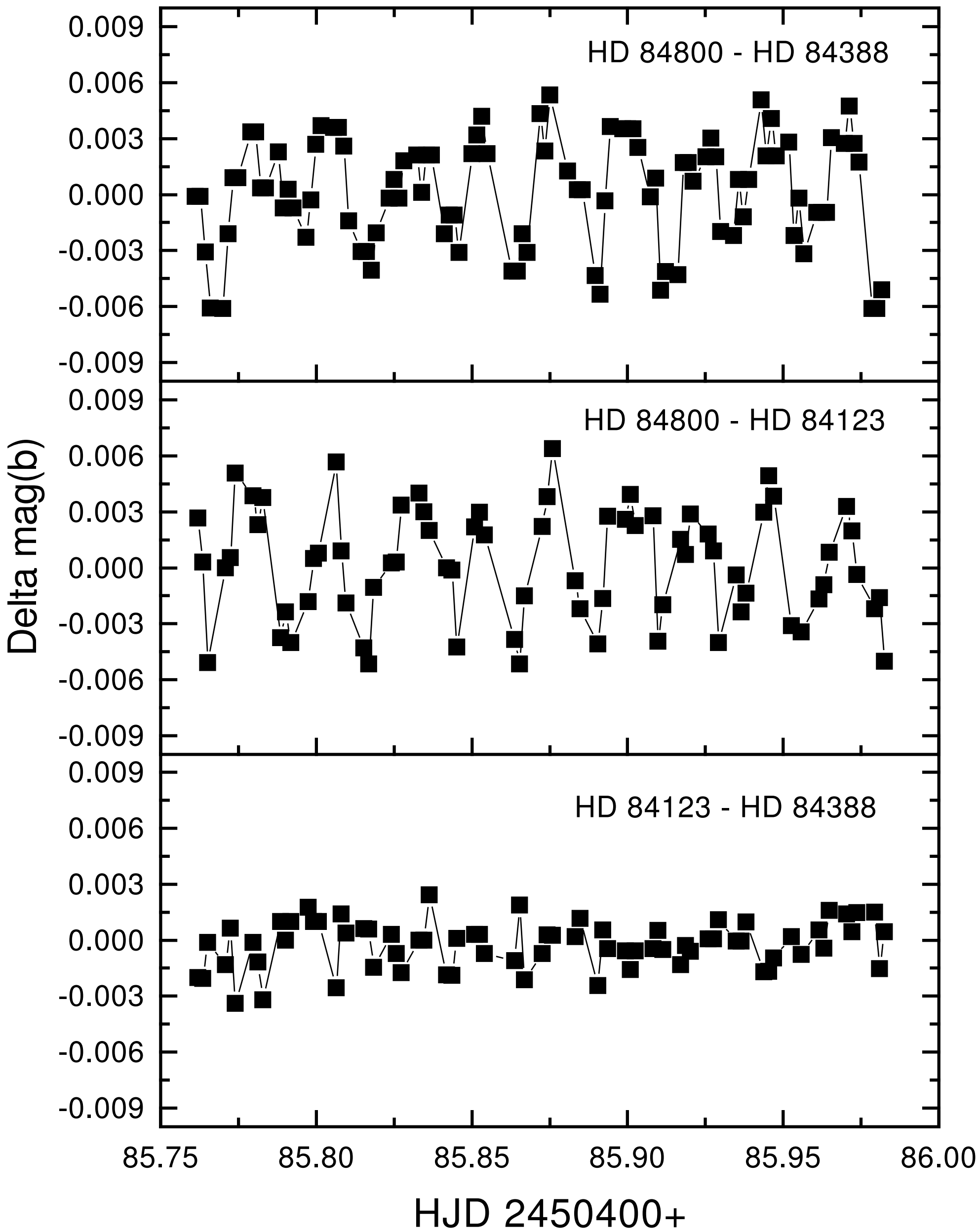

Figure 1. The differential APT light curves for HD 84123, HD 84388 and HD 84800 in Strömgren b

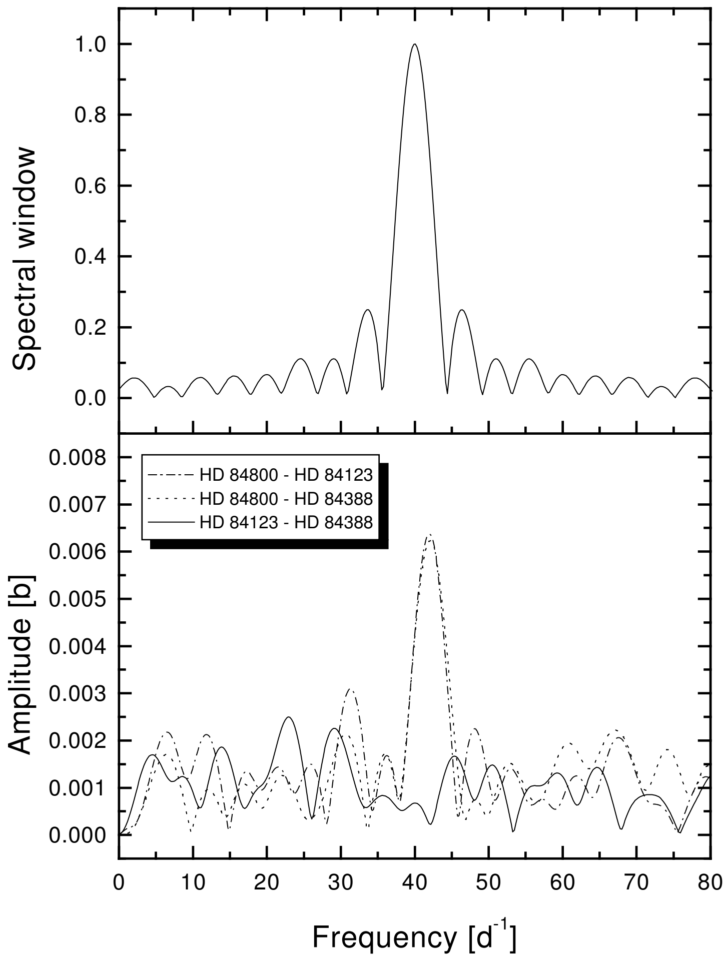

Figure 2. Amplitude spectra for all three stars

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DZ CANIS MAJORIS, A NEW DOUBLE-MODE CEPHEID

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DZ CMa is listed in the GCVS-IV as a classical Cepheid with a period of 1.75434 days. It is of special interest owing to the fact that it is projected on the open cluster NGC 2360. Just a small subset of Cepheids are spatially coincident with open clusters. The only previous photoelectric observations for DZ CMa are 10 measurements by Diethelm (1986). Its light curve is therefore not well defined, which is why we included the star on our program of photoelectric observations for Cepheids.

New observations were made of DZ CMa using a one-channel photometer attached to the 0.5-m telescope of the South African Astronomical Observatory. A total of 28 measurements were obtained (Table 1), mainly in VI_c, from December 25, 1997, to January 3, 1998. The accuracy of the individual data is near $\pm$ 0$^m_.$01 in all filters.

Table 1

JD_{hel} 2450800+	V	$B-V$	$(V-I)_c$	JD_{hel} 2450800+	V	$B-V$	$(V-I)_c$
08.4882	11.766	-	1.282	14.5085	12.350	-	1.467
09.3916	12.346	-	1.447	14.5534	12.367	-	1.476
09.4816	12.227	-	1.454	15.3437	11.889	-	1.319
10.3889	12.052	-	1.365	15.4396	11.956	-	1.348
10.5014	12.037	-	1.354	15.4804	11.940	-	1.328
11.4083	11.904	-	1.324	15.5103	11.955	-	1.349
11.5355	11.967	-	1.349	15.5641	11.968	-	1.351
12.3677	12.313	-	1.456	16.3042	12.060	-	1.381
12.4025	12.300	-	1.436	16.3986	12.076	-	1.406
12.4394	12.313	-	1.460	16.4773	12.102	-	1.404
12.4752	12.345	-	1.474	17.3058	12.206	1.193	1.420
12.5077	12.342	-	1.461	17.3518	12.206	1.238	1.412
12.5401	12.350	-	1.459	17.3930	12.193	-	1.418
14.4925	12.371	-	1.460	17.4335	12.158	-	1.407

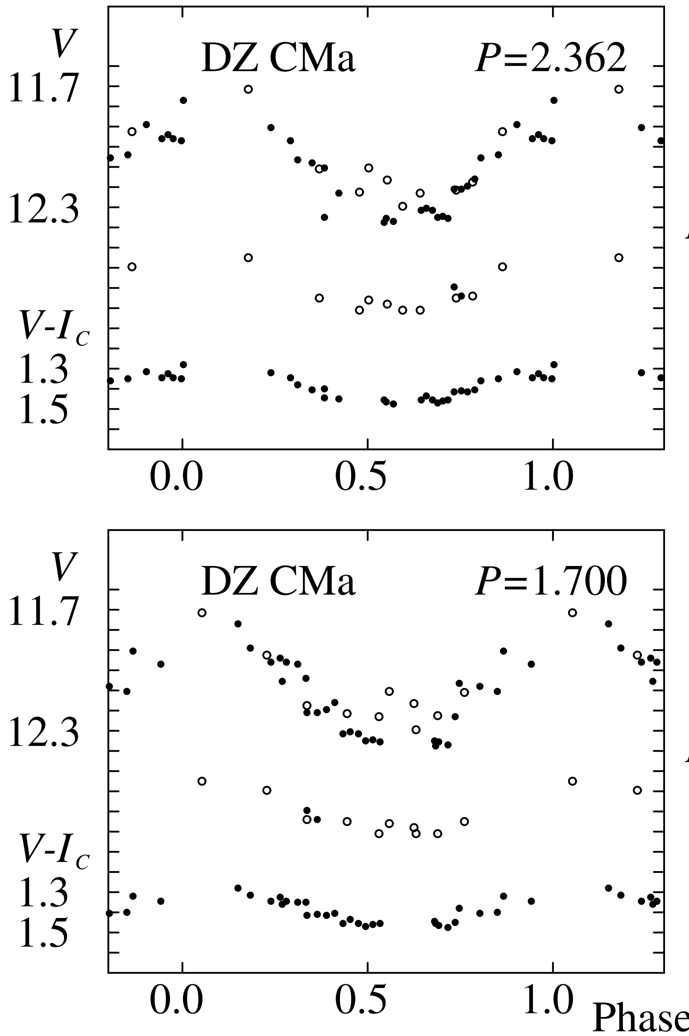

Figure 1.

A frequency analysis of our data in combination with Diethelm's (1986) observations shows that DZ CMa is most likely a double-mode Cepheid with the elements:

fundamental: Max $JD_{hel} = 2450808.48 + 2\overset{d}{.}362896 \times E$,

first overtone: Max $JD_{hel} = 2450808.23 + 1\overset{d}{.}700131 \times E$.

The elements are used in Figure 1 for plotting our observations (dots) with those of Diethelm (circles). The observed period ratio for the two pulsation modes is $f_1/f_0 = 0.7195$, which agrees closely with the results for other double-mode pulsators and is further confirmation that DZ CMa is a beat Cepheid.

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Reference:

Diethelm, R., 1986, *Astron. Astrophys. Suppl. Ser.*, **64**, 261

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CCD PHOTOMETRY OF V1147 Cyg

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Recently Chinarova (1997) published a photographic lightcurve of the eclipsing binary star V1147 Cyg=HBV 426 based on measurements of 144 photographic plates. The lightcurve was generated assuming a period of 1.097382 days found from photographic minima.

Table 1. Observing Journal (HJD − 2450000)

HJD Start	HJD End	Site	HJD Start	HJD End	Site
631.687	631.861	USAFA	702.724	702.784	USAFA
632.675	632.758	USAFA	722.556	722.639	ASU
634.741	634.894	USAFA	724.571	724.786	USAFA
635.666	635.793	USAFA	726.631	726.632	ASU
636.677	636.757	USAFA	731.556	731.718	USAFA
638.648	638.933	USAFA	735.507	753.510	ASU
639.849	639.935	USAFA	737.518	737.690	ASU
640.650	640.787	USAFA	742.503	742.635	ASU
641.726	641.925	USAFA	758.648	758.751	USAFA
642.670	642.883	USAFA	760.479	760.670	ASU
643.705	643.884	USAFA	798.478	798.580	ASU
644.655	644.745	USAFA	798.530	798.600	USAFA
697.906	697.686	USAFA			

During the period of UT 1997 July 2-15 and on several isolated nights thereafter we recorded 272 and 278 images of this star through V and R filters respectively using the 0.61 m telescope at the US Air Force Academy (USAFA) and a liquid nitrogen cooled 512x512 Photometrics CCD. 110 and 9 additional CCD images were taken through V and R filters respectively using the 0.8 m telescope at Appalachian State University (ASU) and a thermoelectrically cooled 1024x1024 Photometrics CCD. All images were flat fielded and then magnitudes were extracted using IRAF software. Additionally, the ASU observations were transformed to USAFA instrumental magnitudes using coefficients derived from stars within the field. Table 1 lists the observing circumstances for all observations.

Our goals included verifying the period, studying the nature of the primary eclipse, and looking for a secondary minimum which was not apparent in Chinarova's lightcurve. We studied five stars in the $3\farcm7 \times 3\farcm7$ field as candidates for comparison stars. Figure 1 is a finder chart made from one of our images that identifies V1147 Cyg and the comparison stars. After examining all images, stars 2, 3 and 4 where chosen as comparison stars due to the stability of their magnitude differences in all seeing conditions. The standard deviations in the R filter differences in magnitude for these stars on 180 USAFA images was about 0.015. All three of these stars are about 13th magnitude and the differential magnitude between V1147 Cyg and the combined light of these stars was calculated for each image.

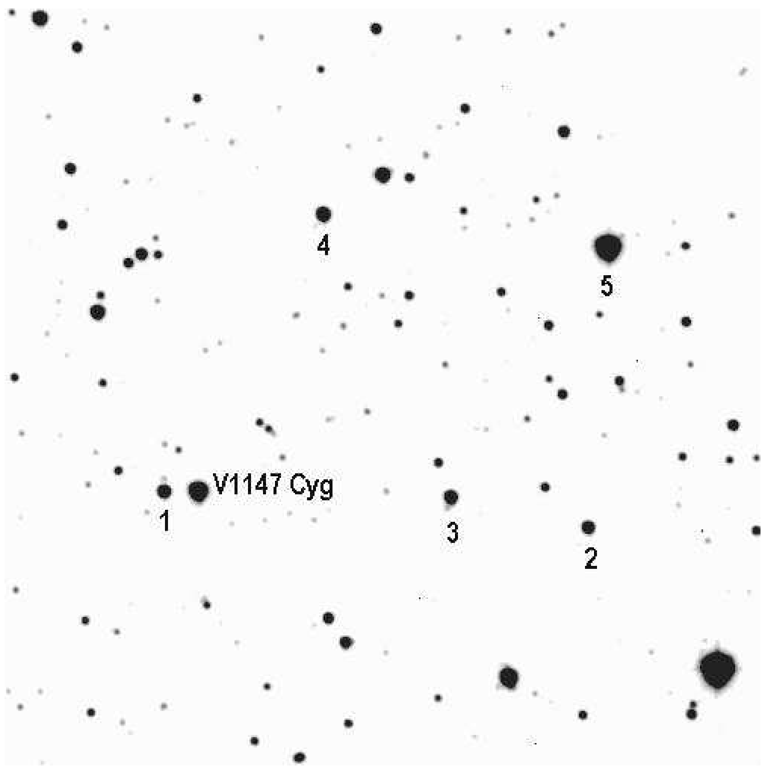

Figure 1. Finder chart for V1147 Cyg ($3\farcm7 \times 3\farcm7$). North is up and East is to the left

Primary minima were observed on UT 1997 July 7, 1997 September 6 and 1997 November 6 of depth 0.75 ± 0.01 in R and 0.77 ± 0.03 in V. The primary eclipse (first to fourth contacts) lasts 7.0 ± 0.3 hours. The observations also revealed secondary minima, observed on UT 1997 October 16 and UT 1997 December 16, of depth 0.59 ± 0.01 in R and 0.57 ± 0.02 in V. Although the secondary eclipse was never observed from minima to either first or fourth contact, when compared to the primary eclipse, the duration of the secondary eclipse (first to fourth contact) appears to be about 1.69 ± 0.05 times the duration of the primary eclipse, and thus lasts 11.8 ± 0.6 hours. The heliocentric Julian date of minima, uncertainty in each minima, and type of minima for these timings are shown in Table 2. Combining these observations reveal the most likely period to be 15.25141

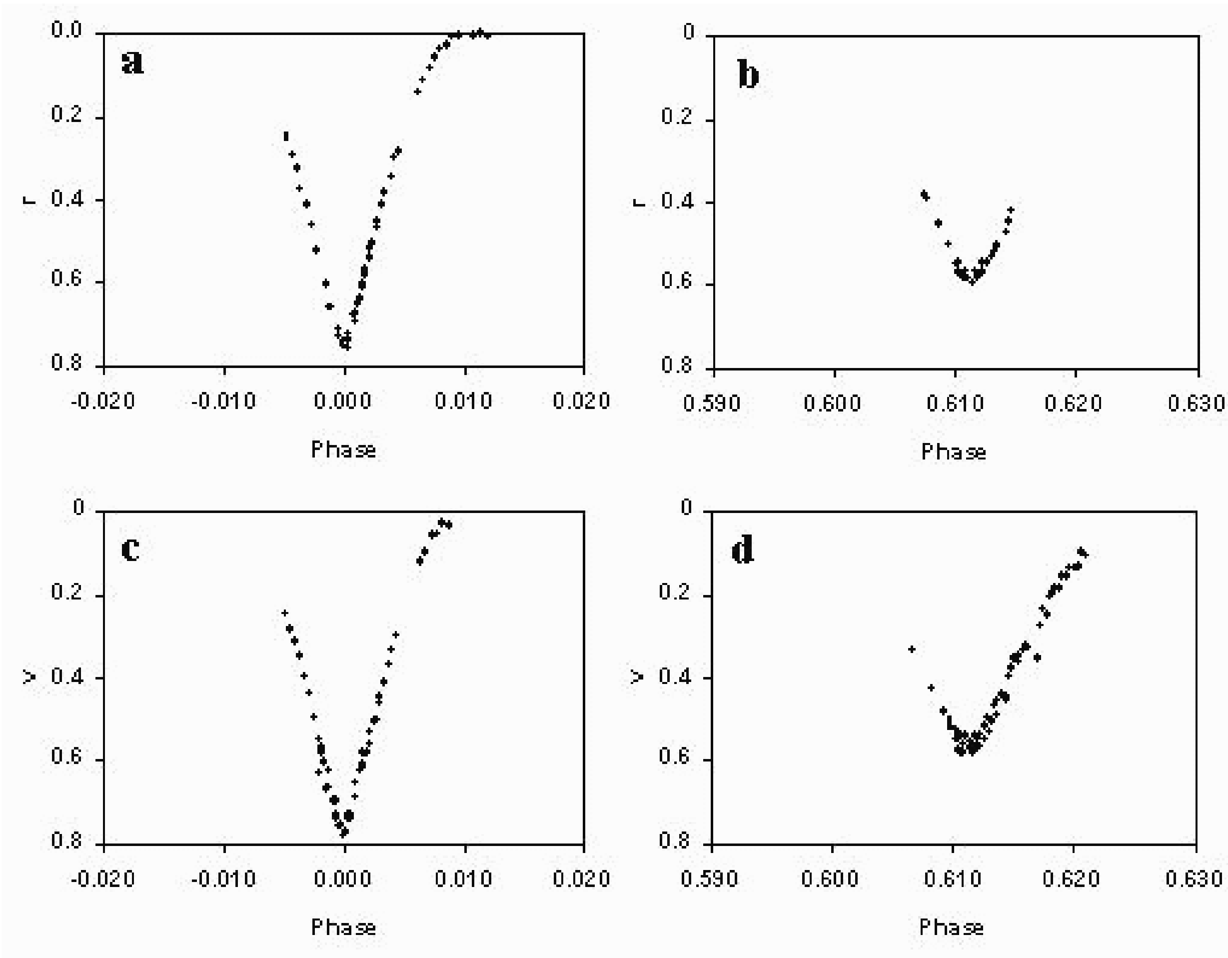

Figure 2. V1147 Cyg lightcurve (instrumental magnitudes): a. primary eclipse in R, b. secondary eclipse in R, c. primary eclipse in V, d. secondary eclipse in V

days, with twice and four times this period also possible. These longer periods (30.50282 days and 61.00564 days), however, can be ruled out by considering visual observations which will be reported elsewhere (Lloyd, in preparation) or by considering Chinarova's "most prominent weakenings". The ephemeris using the three primary minima and two secondary minima presented here is 2450758.7233 ($\pm$ 0.0004) + 15.25141 ($\pm$ 0.00011) $\times$E. The secondary minima occurs at phase 0.6114 ($\pm$ 0.0003). This, along with the fact that the primary and secondary eclipse durations are different, indicate elliptical orbits for the two stars in V1147 Cyg. With this period we present the primary and secondary minima in instrumental V and R magnitudes in Figure 2, where the out of eclipse magnitude of V1147 Cyg has been normalized to zero and the primary eclipse has been centered at zero phase. The light curve between eclipses is flat to within the measured uncertainty.

Table 2. Times of Minima

Epoch (HJD)	Error	Type	Source
2434119.525	0.10	primary	Wachmann, 1966
2434952.358	0.10	secondary	Wachmann, 1966
2436462.3483	0.10	secondary	Chinarova, 1997
2439741.3395	0.10	secondary	Chinarova, 1997
2441150.3982	0.10	primary	Chinarova, 1997
2441544.3847	????	unknown	Chinarova, 1997
2450636.7119	0.0010	primary	This paper
2450697.7158	0.0014	primary	This paper
2450737.5441	0.0009	secondary	This paper
2450758.7233	0.0004	primary	This paper
2450798.5493	0.0005	secondary	This paper

If we combine our data with Chinarova's "most prominent weakenings" (also shown in Table 2), we find that all but one of the minima occur close to either a primary or secondary eclipse. We have estimated the uncertainty in the photographic data for the time of minima to be the amount of time that an eclipse is dimmer than half its mid-eclipse value. Excluding the one timing that does not have a close fit to the ephemeris and using all instances of primary and secondary eclipses, we obtain an ephemeris of 2450758.7233 ($\pm$ 0.0004) + 15.25134 ($\pm$ 0.00003) $\times$E.

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OU Gem AND AT Cap IN 1984/5

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We present broadband photometry and high-dispersion spectroscopy of OU Gem (HD 45088), and spectroscopy of AT Cap (HD 195040). These data are relatively limited in number, but may be of use when compiling a longer term history of the stars' behaviour.

OU Gem:
Broadband differential photometry of OU Gem (V∼7) was obtained with the 0.4-m and 0.6-m telescopes at Siding Spring Observatory (SSO) in 1985 February 05-11, while simultaneous spectroscopic observations (resolution ∼ 0.2 Å) were made of the Ca K emission line using the 1.0-m SSO telescope. Table 1 lists the photometry, in the V band only, relative to the comparison stars. Two, three or four observations were made each night, obtained over one or two hours - the table lists nightly means, timed to the nearest 0.05 d. At this time, OU Gem showed no variation in the V band above observational error (Figure 1). The light curve is known to be of variable amplitude. Bopp et al. (1981) observed a V range from ∼0.02 to 0.045 magnitude over 6 months in 1980. A similar range in amplitude has been observed by Cutispoto (1991, 1992, 1996), and Rodono and Cutispoto (1992). Hence our observations appear to have been made at a time of low activity.

Table 1 – V Photometry of OU Gem, 1985 Feb 05-11. (CS1=HD 45452, CS2=HD 45413)

HJD−244000	OU Gem - CS1	OU Gem - CS2	CS1-CS2
6102.05	−0.947	−1.073	−0.126
6103.10	−0.946	−1.062	−0.117
6105.06	−0.950	−1.063	−0.113
6106.10	−0.948	−1.054	−0.107
6107.10	−0.940	−1.044	−0.105
6108.05	−0.950	−1.074	−0.125
Mean	−0.947	−1.062	−0.116
Std dev	0.003	0.0100	0.008

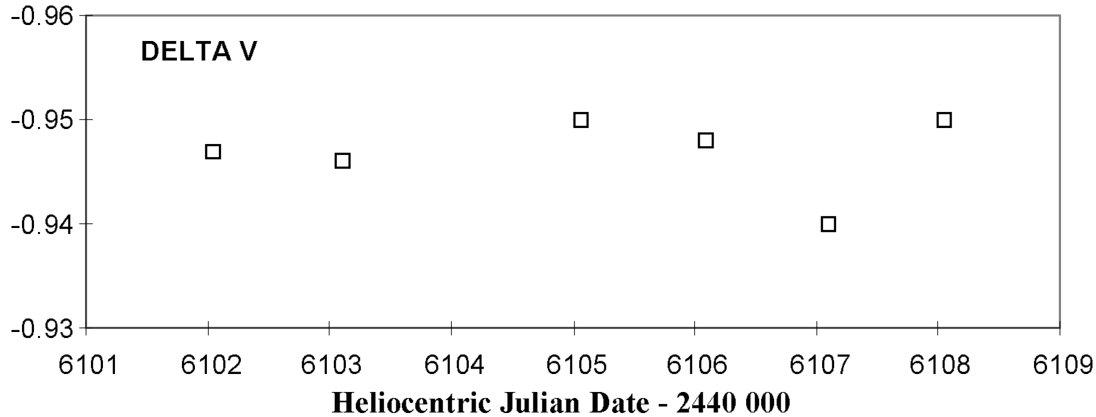

Figure 1. V Photometry of OU Gem - 1985 February

Nightly spectra of the Ca K region of OU Gem were obtained on seven nights in the interval 1985 February 05-12. (February 7 was cloudy.) Emission cores from both components were visible, as noted by Bopp (1980). The secondary emission is weaker than that of the primary, but as the secondary spectrum is otherwise invisible in our (blue) spectra the secondary emission is much stronger (relative to its continuum) than for the primary. The secondary emission may have decreased between the 1979 observations of Bopp (1980) and our 1985 data, which together with the lack of variation in our photometric data may suggest the secondary star is the source of the light variations seen by others.

Radial velocities were derived from cross correlations on the primary spectrum absorption lines, using template stars of known radial velocity, and also from least squares gaussian fits to the primary and secondary emission cores. See Innis et al. (1988) for more details of these procedures. Our measurements listed in Table 2. On one night the primary and secondary K emission cores overlapped; the velocity measured agreed with the cross correlation result from the primary's absorption lines. The radial velocity variation of this star has been well studied by Griffin and Emerson (1975) and Tomkin (1980). Plotting our data with the elements determined by Griffin and Emerson (1975) gives a good fit between our data and the earlier sets (see Figure 2, where we use P = 6.991868 d, Epoch = HJD 2440203.163 from Griffin and Emerson, 1975). Four more recent radial velocity measurements presented by Gunn et al. (1996) are also satisfactorily described by these elements, implying no revision is required.

Table 2 – Spectroscopic data for OU Gem, 1985 February 05-12.
Heliocentric Radial Velocity (km s^{-1})

HJD − 2440000	Cross Correlation	Ca K emission: Primary	Secondary
6101.99	+18.6	+18.7	−52.9
6103.02	+42.2	+44.6	−81.2
6105.01	−42.3	−45.4	+22.9
6106.03	−62.0	−66.4	+54.3
6107.05	−44.5	−46.9	+29.2
6108.02	−10.8	−10.9	–
6109.01	+25.5	+24.6	−51.1

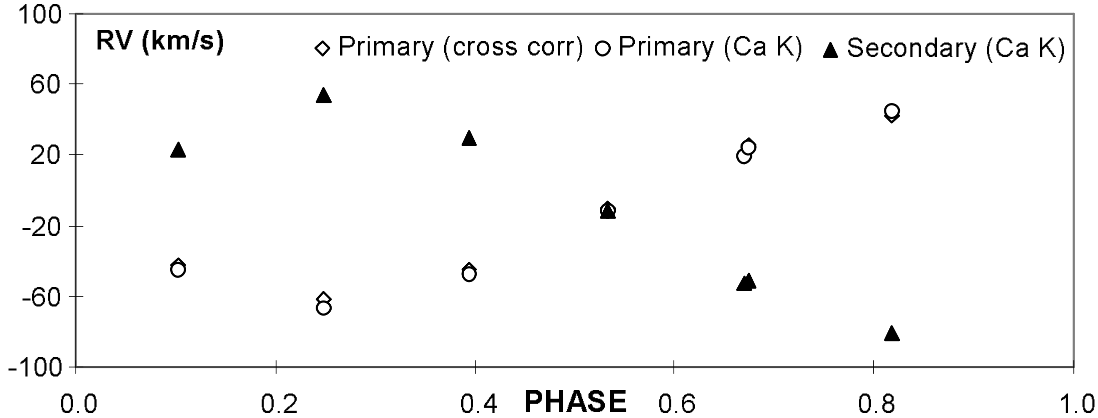

Figure 2. Radial velocity versus orbital phase for OU Gem

AT Cap

Balona (1987) presented 35 radial velocity observations of this single-lined binary, deriving an orbital period of 23.206±0.018 days, with a velocity semi-amplitude of 21.9 km s^{-1}. Collier (1987) obtained nine observations of this star, also demonstrating velocity variability. Lloyd Evans and Koen (1987) reported photometric variability commensurate with the orbital period. We obtained 12 radial velocity observations of AT Cap, mostly around 3 years after the Balona and Collier data, from cross correlation on the star's absorption spectrum. Our measurements are given in Table 3. Performing a Lomb-Scargle periodogram analysis on all 56 measurements of the radial velocity yielded a period of 23.20±0.03 days, which within the error agrees with the finding of Balona (1987), but does not refine the period.

Table 3 – Radial velocity data for AT Cap

HJD − 2440000	Heliocentric Radial Velocity (km s^{-1})
5927.983	−39.9
5928.153	−40.3
5978.966	−25.8
5978.997	−21.5
5979.935	−12.2
5980.053	−16.0
5980.945	−4.4
5981.924	−0.5
5982.917	+3.3
5983.941	+7.2
5985.934	+6.5
6305.063	+6.4

Our data are plotted with the earlier work of Balona (1987) and Collier (1987) in Figure 3, using an epoch = HJD 2444353.1 and P = 23.206 d (Balona, 1987). The velocity curve shows some scatter, but trying slightly different values of the orbital period does not reduce the discrepancies. Five measurements (three of ours, two of Balona's) appear too positive by 10 to 20 km s^{-1} (near phases 0.2, 0.28 and 0.43) for reasons we cannot account for, but which may be due to nothing more significant than observational error together with possible systematic differences between the two data sets.

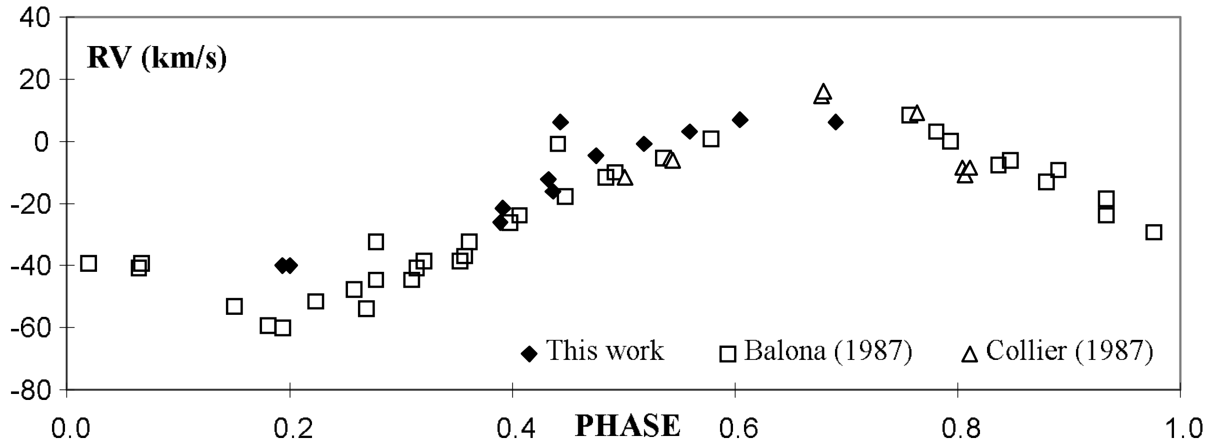

Figure 3. Radial velocity versus phase for AT Cap

We thank Mount Stromlo and Siding Spring Observatories for access to their telescopes and data reduction software.

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PHOTOMETRY AND SPECTROSCOPY OF V841 Cen IN 1984/5

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During a programme of study of active-chromosphere stars in the 1980s we obtained photometric and spectroscopic data on the single-lined binary V841 Cen (HD 127535). Collier (1982) performed the first extensive observations of the system, finding a V range of 0.07 magnitude, and a radial velocity variation with a 6 day period. Udalski and Geyer (1984) obtained photometry in 1984 April, finding the V range had increased to 0.25 mag. Our initial data were presented in Innis et al. (1985). A more extensive discussion incorporating later results appeared only in the unpublished thesis of Innis (1986). The orbital period of just over 6 days derived in Innis et al. (1985) was revised to 5.988 days in Innis (1986), in agreement with the work of Collier (1982). Since then studies by e.g. Strassmeier et al., 1994; Cutispoto et al., 1996, and references therein, have added to the understanding of this object. As our data may be of interest when considering the long term behaviour of this star, we present our observations here.

Differential photometry of V841 Cen was obtained with the 0.4-m and 0.6-m telescope at Siding Spring Observatory (SSO). In 1984 UBVR$_C$ data were obtained on six nights during August 03-09. In 1985 V data were collected on five nights during February 05-11, and on April 06, 07, 08, and 09. The comparison stars used were HD 128277 and HD 127724. Observations of E-region standard stars allowed us to transform the data to standard magnitudes. The magnitudes and colours of the comparison stars are in Table 1, along with representative maximum light values for V841 Cen. The mean V difference between the comparison stars was 1.913±0.010 and 1.908±0.013 in 1984 and 1985 respectively. Our photometry of V841 Cen is given in Table 2. Figure 1 shows the multi-colour photometry from 1984. Figure 2 (left panel) shows the 1985 V photometry. We use an epoch of HJD 2444653.737 and a period of 5.988 days for all the plots here.

Table 1 – Magnitudes and colours of target and comparison stars

Star	V	B−V	V−R
V841 Cen	8.6	1.06	0.61
HD 128277	8.30	1.05	0.54
HD 127724	6.39	1.26	0.63

Table 2 – Photometry of V841 Cen.

1984 Observations 1985 Observations

HJD−2440000	V	B−V	V−R_C	U−B	HJD−2440000	V	HJD−2440000	V
5916.044	8.652	1.064	0.610	0.897	6102.223	8.650	6108.236	8.660
5916.050	8.661	1.055	0.610	0.893	6102.244	8.660	6162.274	8.689
5917.000	8.721	1.059	0.619	0.877	6102.259	8.651	6162.278	8.694
5918.965	8.641	1.072	0.606	0.877	6103.185	8.774	6162.292	8.694
5919.000	8.662	1.103	0.612	0.914	6103.204	8.771	6163.054	8.836
5919.963	8.606	1.040	0.607	0.895	6103.223	8.782	6163.062	8.824
5919.976	8.603	1.056	0.599	0.867	6106.058	8.596	6164.169	8.790
5920.884	8.604	1.051	0.601	0.837	6106.069	8.589	6164.175	8.772
5920.902	8.608	1.045	0.601	0.850	6107.211	8.645	6164.183	8.765
5920.922	8.610	1.044	0.606	0.858	6107.225	8.625	6165.165	8.614
5920.943	8.607	1.053	0.597	0.846	6107.237	8.641	6165.171	8.609
5920.964	8.610	1.050	0.605	0.870	6108.203	8.673	6165.178	8.619
5920.984	8.616	1.052	0.603	0.851	6108.220	8.646	-	-
5921.979	8.659	1.061	0.610	0.867	-	-	-	-
5921.992	8.666	1.059	0.615	0.863	-	-	-	-

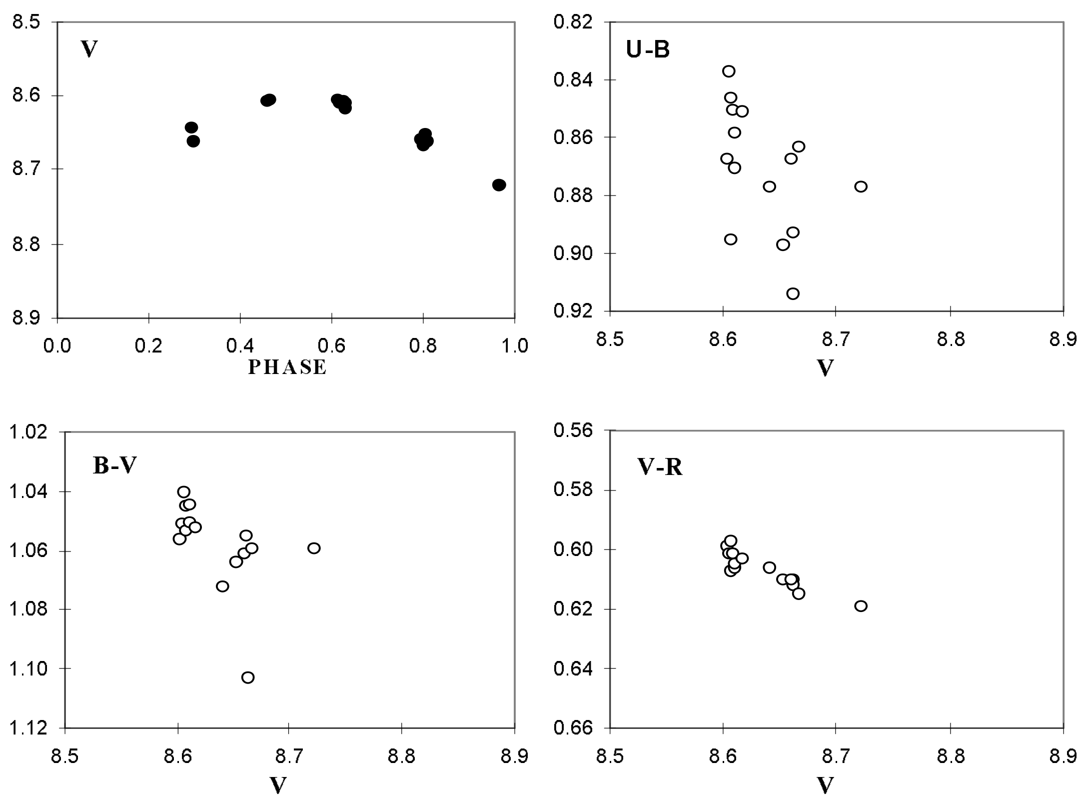

Figure 1. Photometry of V841 Cen in 1984

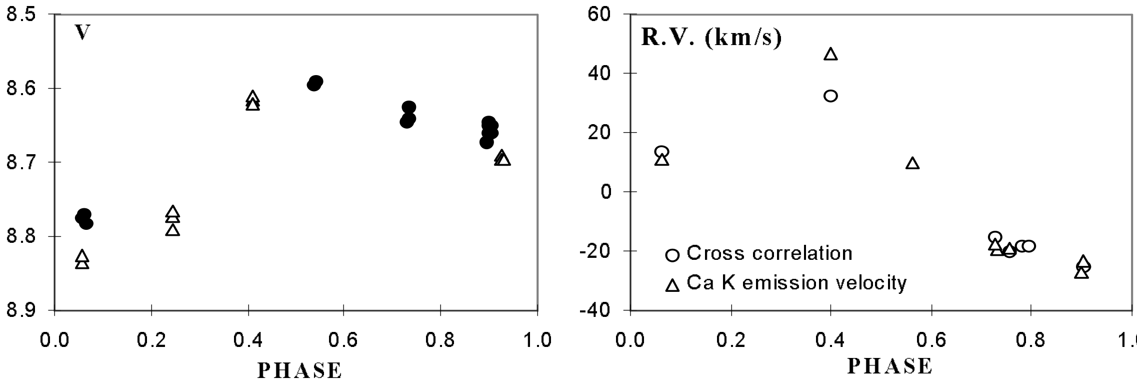

Figure 2. 1985 Photometry (left) and Radial velocity data (right) for V841 Cen

Digital spectra (resolution ~0.2 Å) were obtained with the 1.0-m SSO telescope in three runs: 1984 August (H-alpha), 1985 February, and 1985 August (Ca K). The two spectra from the first run showed H-alpha as a symmetric emission feature. Radial velocities were determined by cross correlation on absorption line features using template stars of known radial velocity. For the later data the radial velocity of the Ca K emission peak was determined, as was the Ca K emission peak equivalent width. See Innis et al. (1988) for more details of the procedures used. The results are given in Table 3. Radial velocities are heliocentric, and are in km s^{-1}, while Ca K equivalent widths are in Angstroms. Unfortunately the cross correlation velocity for HJD 2446101.228 and the Ca K equivalent width for HJD 2446304.969 appear not to have been calculated. The two asterisked values of radial velocity are for spectra that show low cross correlation maxima. We recommend that they not be included in any further analysis. Our radial velocity data are plotted in Figure 2 (right panel).

Table 3 – Spectroscopic observations for V841 Cen

HJD–2440000	RV (cross corr.)	RV (Ca K emiss)	Eq width Ca K (Å)
5927.879	−18.1	–	–
5927.941	−18.3	–	–
6101.228	–	−19.6	2.42
6102.221	4.8 (⋆)	−26.8	1.11
6103.221	13.6	11.2	1.74
6105.214	32.4	46.8	3.52
6106.211	19.8 (⋆)	9.9	1.70
6107.183	−14.8	−17.3	6.46
6108.238	−24.9	−23.3	5.29
6304.969	−20.0	−19.0	–

The V light curve is of amplitude ~0.1 magnitude in the 1984 August data, about half that observed by Udalski and Geyer (1984) a few months earlier, but had increased to ~0.2 mag in 1985. The light curve in 1985 was not stable, data taken in February deviating from those obtained at similar phases in April (shown as open triangles in Figure 2). There is also a small colour change apparent in the 1984 data, the star being bluest when brightest.

There is generally good agreement between the radial velocities determined from cross correlations using the absorption line spectra and those determined from least-squares fits to the Ca K emission, usually to within the experimental error of a few km s^{-1}. The changes in the Ca K emission equivalent width are quite marked, and exceed the estimated error (of ∼0.5 Å) by a considerable factor. There is no correlation with photometric phase (Figure 3). The spectra in question were carefully examined, and it was concluded that the variations were not due to either computational errors or poor signal-to-noise ratio spectra. Such emission strength changes, if real, are almost unprecedented. This star is a strong microwave flaring source (e.g. Innis et al., 1985; Slee et al., 1987). Hobbs et al. (1979) observed an increase of around a factor two in the Ca K emission of the very active binary V711 Tau (HR 1099) over four nights, during a microwave radio outburst. It may be that V841 Cen shows similar Ca K enhancement during radio flares, but further, simultaneous, data are required.

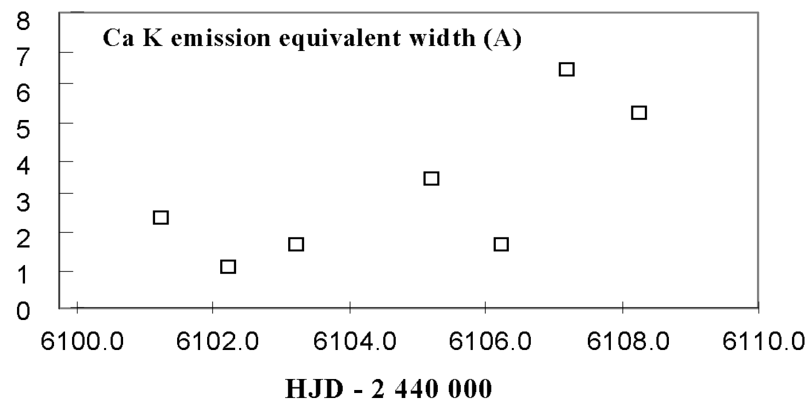

Figure 3. V841 Cen Calcium K emission strength, 1985 Feb

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PULSATING AGB STAR IN THE SYMBIOTIC NOVA PU VULPECULAE

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PU Vul is well known very slow eclipsing symbiotic nova, which exhibited outburst in 1979. The nova reached its maximum in 1983 (B = 8.9, V = 8.33). From that time the nova fades. The light-curve of the nova exhibited two minima in 1980-2 and 1993-4, explained by Vogel & Nussbaumer (1992) and Nussbaumer & Vogel (1996) as eclipses of an outbursted white dwarf by a red M4-6 giant. The pre-outburst B light curve of PU Vul taken in years 1898-1956 showed brightness fluctuations between 14 and 15 mag (Liller & Liller, 1979). Its period analysis confirmed the presence of eclipses on the 4900 day orbit and revealed another significant period $P = 231.5$ days (Chochol et al., 1997). The same period, found by Chochol et al. (1997) in J,H,K postoutburst photometry taken by Belyakina et al. (1985, 1990) and Kenyon (1986), was explained by pulsations of the AGB variable. Its bolometric luminosity $M_c^{bol} = -4.29$ ($L_c = 4100$ L$_\odot$) can be easily derived using the empirical period-luminosity relation of Hughes and Wood (1990) valid for AGB variables (Miras and SRa's).

Chochol et al. (1997) proposed that PU Vul is a triple system. The inner binary with an orbital period of 760 days consists of an outbursted white dwarf (its luminosity during the F5 supergiant mimicry stage was $L_h = 23900$ L$_\odot$) and the AGB or bright M giant with luminosity $L_c^{inn} = 5100$ L$_\odot$. The third component is an M type AGB variable ($L_c^{out} = 4100$ L$_\odot$) on 4900 days outer orbit. The luminosities of the cool components were determined from the primary and secondary eclipse in an outer orbit using the infrared K passband observations. The distance of PU Vul determined from the luminosity of the hot component and E(B-V) = 0.39 (Belyakina et al., 1985) is $d = 5.3$ kpc.

The aim of our paper is to give an independent proof of the presence of the AGB variable in PU Vul using the photoelectric observations in V and R passbands and to show, that in 1995-8 the period of pulsations was $P = 217$ days.

Photoelectric U,B,V,R observations of PU Vul were obtained in 1995 - 98 at the Skalnaté Pleso (SP) and Stará Lesná (SL) observatories of the Astronomical Institute of the Slovak Academy of Sciences. In both cases 0.6 m Cassegrain telescope equipped with a single-channel pulse-counting photoelectric photometer was used. The stars HD 193706 = BD +21°4167 (V = 7.84, B = 9.48, U = 11.46, sp. type K5) and BD +21°4165 (V = 9.23, B = 9.80, U = 9.79, sp. type F8) served as a comparison and check star, respectively. The data reduction, atmospheric extinction correction and transformation to the standard international system were carried out by the usual way. The photoelectric light-curves in U,B,V and R passbands are plotted in Fig. 1.

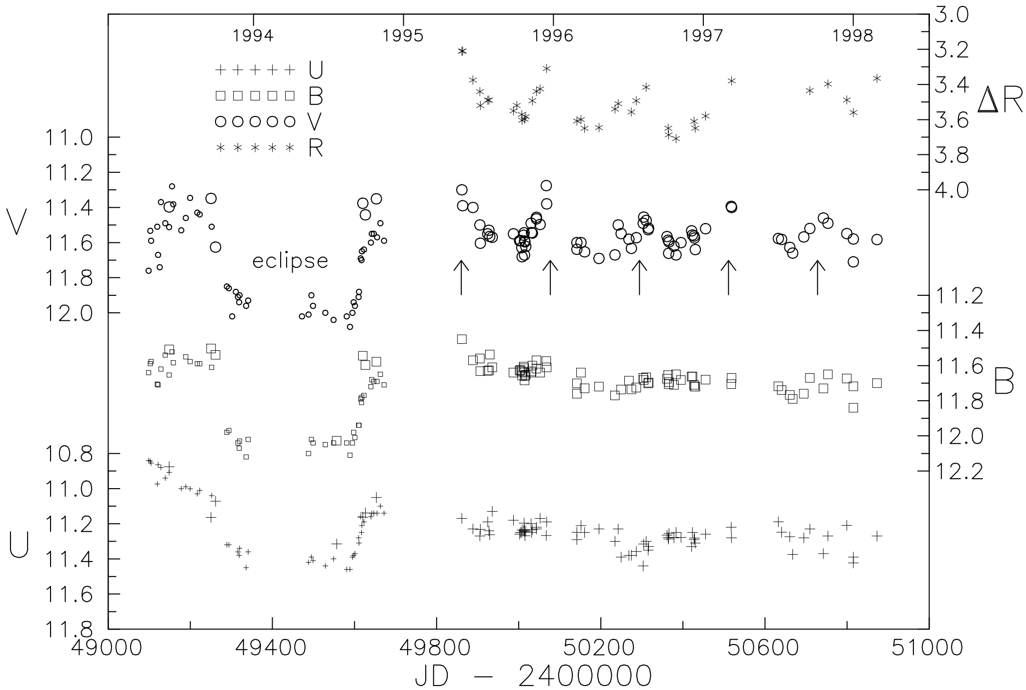

Figure 1. U,B,V and R light-curves of PU Vul since January 1993. The data till January 1995 were taken from Hric et al. (1994, 1996), Skopal et al. (1995) and Kolotilov et al. (1995). The observations taken at SP and SL are denoted by large symbols. The brightness maxima in V and R passbands are marked by arrows

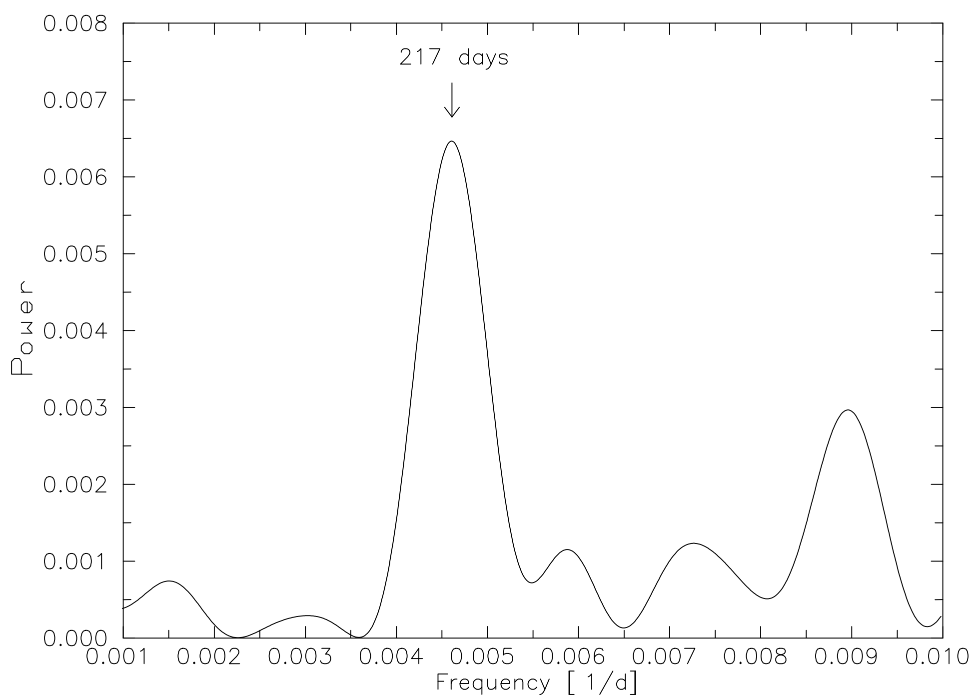

Figure 2. The power spectrum of our V observations taken since 1995

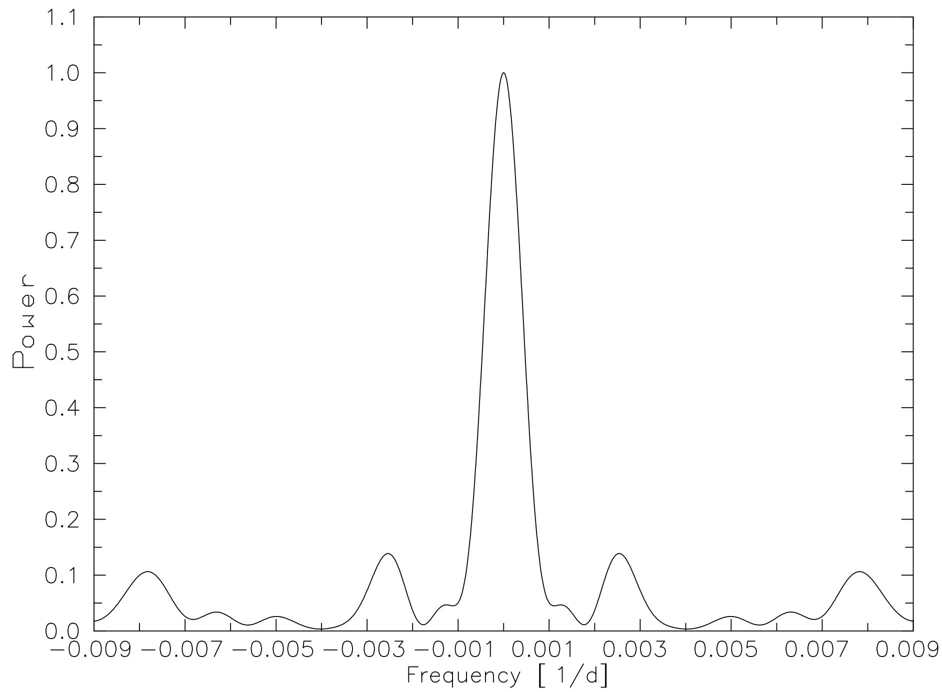

Figure 3. The spectral window corresponding to the power spectrum

It is clearly seen that the light-curve variability of PU Vul increases from U to R colour, so the source of variations is the cool component. The Fourier analysis of the V data in the interval 100 - 1000 days revealed the most significant period at 217±20 days (Figs. 2 and 3). The mean error was determined from the halfwidth of the spectral window. Corresponding phase diagram of the pulsating AGB component is displayed in Fig. 4. The brightness maxima can be predicted using the following ephemeris:

$$JD_{max} = 2\,449\,860 \ + \ 217 \times E. \tag{1}$$

The luminosity of the AGB variable can be derived using the period-luminosity relation of Hughes and Wood (1990):

$$M_c^{bol} = -4.39 - 2.91(\log \ P - 2.4), \tag{2}$$

valid for $P \leq 450$ days. Period of pulsations $P = 217$ days gives $M_c^{bol} = -4.205$ or L_c = 3820 $L_\odot$ (supposing $M_\odot^{bol} = 4.75$ (Allen, 1976)). The effective temperature of the M4 Mira star, corresponding to the period of pulsation 217 days, is $T_{eff} \approx 2700$ K (Allen, 1976). Its radius and mass can be determined using the Stephan-Boltzmann law and the standard pulsation equation (e.g. Feast, 1996)

$$\log P = 1.5 \log R - 0.5 \log M + \log Q, \tag{3}$$

where stellar radius R and mass M are in solar units and Q is the pulsation constant, taken to be 0.04, a value appropriate for overtone pulsation. These relations give R_c = 282 $R_\odot$ and $M_c = 0.76$ $M_\odot$.

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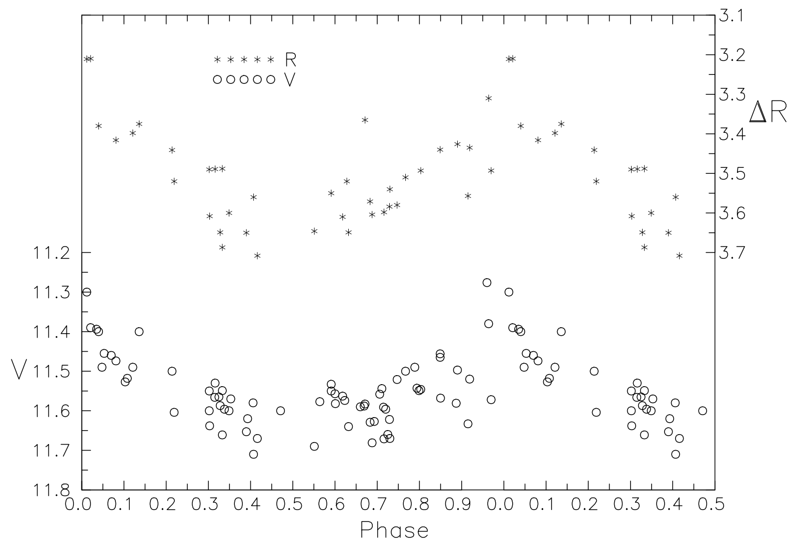

Figure 4. V and R phase diagrams for $P = 217$ days constructed from our observations since 1995

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Ba II LINE AS CEPHEID LUMINOSITY INDICATOR. I

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Absolute magnitudes of the supergiant stars are the values of paramount importance for stellar evolution theory and investigation of galactic structure. The period–luminosity relation for pulsating stars, which is frequently used for rapid M_v determination, has nevertheless two limiting factors: it cannot be applied in case of the non-variable supergiants and, at least for galactic Cepheids, it does not allow to find an accurate absolute magnitude if we do not know exactly about the excited pulsational mode of the investigated star. In particular, such a problem arises in connection with so-called galactic s-Cepheids.

Spectroscopic luminosity indicators (provided they are reliably calibrated), in this sense, are more universal tool of M_v determination for various kinds of supergiant stars. For example, Sorvari (1974) and Baker (1974) applied O I 7774 Å line (triplet) as a luminosity indicator for F-supergiants.

Table 1. Ba II line equivalent widths in spectra of program stars

Star	Period	Phase	W(5853),mÅ	M_v
V473 Lyr	1.4908	0.899	244	−2.25
		0.095	251	
		0.793	247	
		0.559	253	
		0.136	248	
EU Tau	2.1025	0.758	183	−2.69
IR Cep	2.1141	0.137	175	−2.69
DT Cyg	2.4991	0.774	222	−2.90
V526 Mon	2.6750	0.674	191	−2.99
SZ Tau	3.1484	0.501	217	−3.19
		0.573	239	
		0.577	228	
α UMi[1]	3.9696	0.516	275	−3.49
		0.775	256	
		0.015	239	
		0.775	228	
V1162 Aql	5.3761	0.273	267	−3.87
V924 Cyg	5.5715	0.702	266	−3.91
V440 Per	7.57	0.080	283	−4.30
		0.534	310	
FN Aql	9.4816	0.464	320	−4.58
		0.525	315	
		0.841	317	
SZ Cas	13.6377	0.047	315	−5.04
Y Oph	17.1269	0.530	342	−5.33

Remarks: 1 – W values are from Sanval et al. (1988)

In this paper another luminosity indicator is proposed. In contradiction to near-infrared O I triplet, its location in the spectrum is more favourable for spectroscopic observations. Below it will be shown that Ba II 5853.6 Å line appears to be a rather sensitive indicator of the luminosity of supergiants. Its equivalent width depends upon luminosity of the star as a result of the increasing of non-LTE effects in stellar atmosphere with the luminosity increase.

At the first step of the study, an existence of the possible relation between equivalent width of Ba II 5853.6 Å line and M_v was investigated only for small-amplitude s-Cepheids. Equivalent widths measured in the spectra of the program stars are listed in Table 1.

To investigate a possible dependence between Ba II line equivalent width and luminosity (or absolute magnitude M_v) we first calculated M_v for program Cepheids using recent results by Gieren & Fouqué (1993):

$$M_v = -2.9 \times logP - 1.30 \quad (1)$$

Pulsational periods were selected from Fernie et al. (1995) catalogue. The s-Cepheids are assumed to be overtone pulsators. Therefore for those stars we used observed period as the first overtone one P_1. Period of the fundamental mode P_0 for each s-Cepheid was determined using a period ratio P_1/P_0=0.7 (see Szabados, 1997).

Equivalent width of barium line was precisely measured for all the program stars using the spectra collected with an echelle spectrometer LYNX on 6-m telescope (Special Astrophysical Observatory of the Russian Academy of Sciences, Russia, Northern Caucasus; the detailed description of the spectrometer is given by Panchuk et al., 1993), AURELIE spectrograph (Gillet et al., 1994) on the 1.52m telescope of Haute Provence Observatory (France) and with ELODIE, a fibre-fed echelle spectrograph installed on the 1.93m telescope of Observatoire de Haute-Provence, France (Baranne et al., 1996 give detailed descriptions of the spectrograph). Some of the collected spectra were previously analysed (for determination of elemental abundances) in several papers by Andrievsky et al. (1996), Kovtyukh et al. (1996), Andrievsky et al. (1998). The necessary information about the spectra of program stars (telescope, spectrograph, resolving power, S/N ratio), as well as information concerning the procedure of the equivalent width measurements, can be found in the above mentioned works. The internal accuracy of the equivalent widths is of the order of 5%. This estimate is based on the comparison of values derived from the lines presented in two overlapping spectral orders.
Note also, that in none of those works the Ba II lines were used for abundance determination. The main problem is connected with their large equivalent widths that completely excludes an application of LTE approach for abundance analysis.

The relation $M_v - W(BaII\ 5853.6\ Å)$ is shown in Fig. 1 for program s-Cepheids. Very clear dependence between visual absolute magnitude and equivalent width of Ba II 5853.6 Å line is seen.

Taking into account that s-Cepheids are small-amplitude pulsators, one can expect that equivalent width variations during the pulsational cycle will be small (it is confirmed, e.g. by V473 Lyr data, see Table 1).

The least squares fit for $M_v - W(BaII\ 5853.6\ Å)$ relation is following:

$$M_v = -0.016 \times W(5853) + 0.28 \quad (2)$$

The unusual Cepheid V473 Lyr strongly deviates from the least squares fit found for s-Cepheids. Even supposing that it pulsates in the second overtone (see Andrievsky et al.,

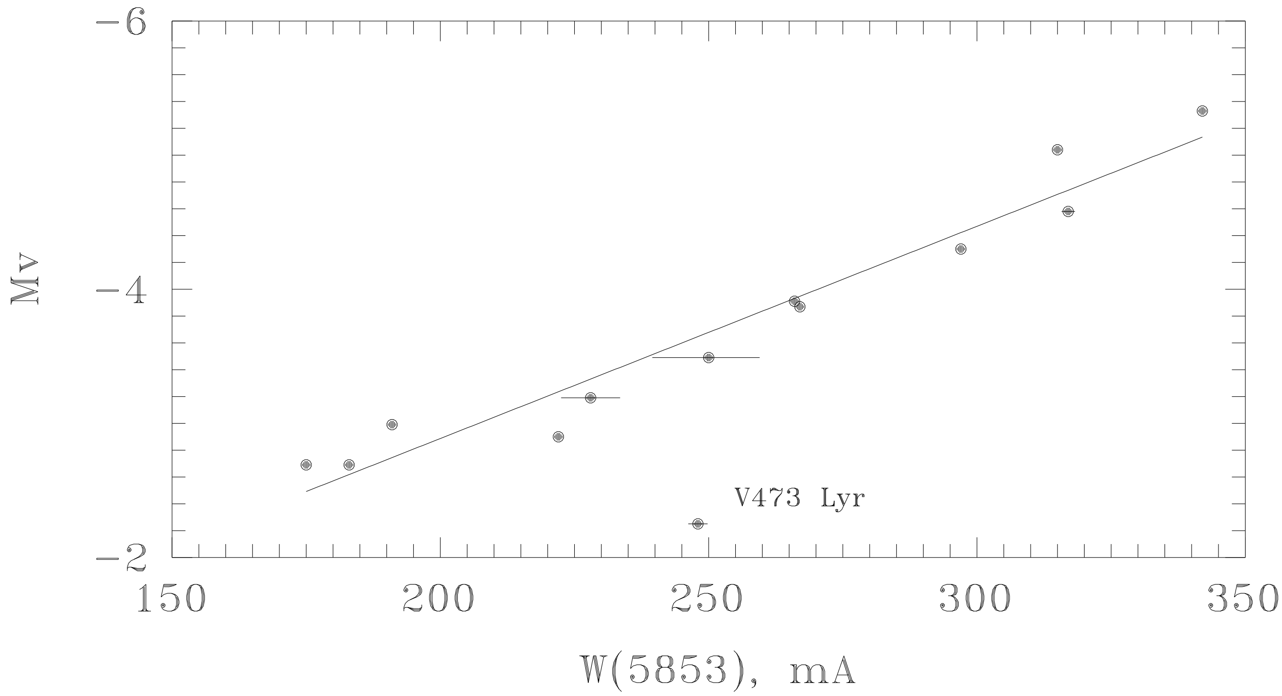

Figure 1. M_v vs. Ba II 5853.6 Å line equivalent width for s-Cepheids. Horizontal lines indicate σ values

1998), we can not adjust its calculated absolute magnitude with the predicted one from the sample of investigated s-Cepheids.

A careful investigation of the possible relations between equivalent widths of Ba II 5853.6 Å and 6141.7 Å lines and absolute magnitude for a sample of classical Cepheids and non-variable F−G supergiant will be a subject of the next paper.

Of course, the relations between M_v and equivalent width of Ba II 5853.6 Å will not substitute a dependence between absolute magnitude and pulsational period for Cepheids which is usually used by the specialists. Nevertheless, the found relation given in Eq.(2) can be considered as a complementary one, allowing to reveal in some cases unusual Cepheids (pulsating in high overtones) and to determine absolute magnitudes for non-variable supergiants using, in particular, spectra collected for those stars during previous years.

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SPECTROSCOPIC AND PHOTOMETRIC VARIATIONS OF HR 5

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We report on the discovery of radial velocity variations of the B component of the visual binary HR 5AB (=ADS 61, A-B separation: $1''\!.455\pm0''\!.004$; ESA 1997) with an orbital period of 1.026 days. Simultaneous photometric observations confirm the low-amplitude variability of similar periodicity originally discovered by Brettman et al. (1983). HR 5AB is a bright (V$\approx 6^{\rm m}$) visual binary with a period of 106.83 years (Baize 1943, Lippincott 1963). Component A has been classified as dG4 and component B as dG8 (see Wilson 1953), but Lippincott (1963) found individual masses of 1.3 $M_\odot$ and 1.5 $M_\odot$, respectively and already noted that the fainter star is also the more massive.

Our spectroscopic data were obtained at the National Solar Observatory (NSO) with the McMath–Pierce telescope and the stellar spectrograph with a 800^2 TI CCD (TI-4 chip, 15μ pixels). The resolving power was R=40,000 and covered a useful wavelength range of about 45 Å. The observations were made within a two-month interval between October 31, 1996 and January 8, 1997 and consist of a total of 23 spectra centered at 6430 Å. The radial velocities were obtained from cross correlating the HR 5 spectra with nightly spectra of the IAU velocity standard α Ari ($v_{\rm r}=-14.3$ km s^{-1}).

The photometric data were obtained with the Wolfgang 0.75-m automatic photoelectric telescope (APT), part of the Vienna Wolfgang-Amadeus twin APT at Fairborn Observatory in southern Arizona (Strassmeier et al. 1997). The observations were made differentially through Strömgren b and y filters with respect to HD 663 as the comparison star (V=6.68 mag, B−V=1.212), and HD 224784 as the check star (V=6.18 mag, B−V=1.032). Altogether, 48 data points were gathered between JD 2,450,395 and JD 2,450,441 and 7 additional points between JD 2,450,625 and 2,450,630.

Table 1. Preliminary orbital elements of HR 5B

Orbital element	Value
P (days)	1.0260±0.0013
T_0 (HJD)	2,450,393.95
γ (km s^{-1})	–12.1±0.6
K_1 (km s^{-1})	8.1±0.9
e	0.0 (adopted)
$a_1 \sin i$ (km)	$0.114\pm0.013 \times 10^6$
$f(M)$	$0.57\pm0.19 \times 10^{-4}$

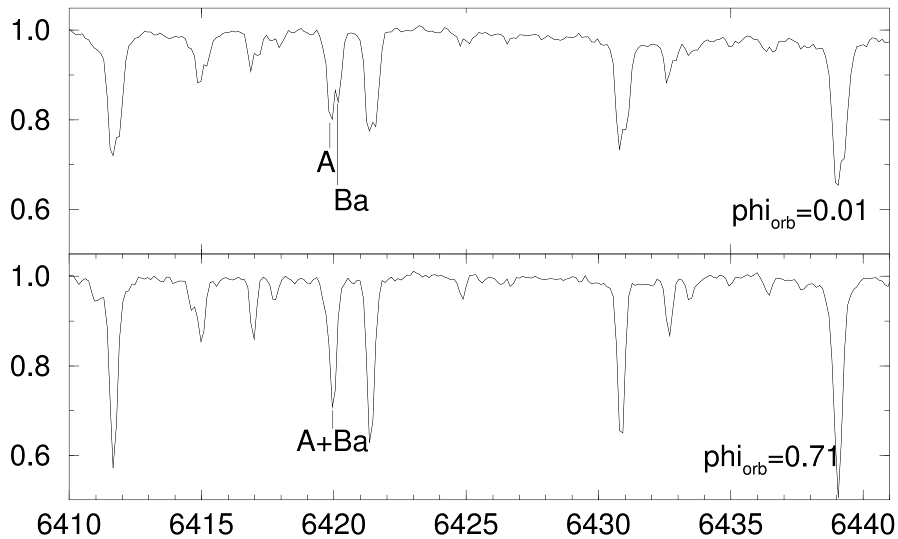

Figure 1. Two representative spectra of HR 5 taken on Dec. 2, 1996 (JD 2,450,420, top panel) and on Dec. 14, 1996 (2,450,432, bottom panel). HR 5A is the stationary component and Ba the variable but always red-shifted component with respect to A.

Figure 1 shows two representative spectra where the AB components are either clearly resolved (top panel) or blended (bottom panel). The stronger line is identified with the stationary A component while the weaker line is due to the variable Ba component. The Bb component is invisible. To measure precise radial velocities, we fitted two Gaussians to the doubled cross-correlation peaks. The resulting velocities for the A and Ba component are plotted in Figure 2. The standard error of a measure of unit weight is 1.1 km s^{-1} for component A and 4.0 km s^{-1} for component Ba. To estimate the projected rotational velocities of the two components, we also fitted two Gaussians to the blended spectral lines and obtained $v \sin i(\mathrm{A}) = 4.7{\pm}1.7$ km s^{-1} and $v \sin i(\mathrm{Ba}) = 4.7{\pm}1.3$ km s^{-1} for component A and Ba, respectively. A radial-tangential macroturbulence model of 3 km s^{-1} has been adopted for both components according to Gray (1992).

A period analysis of the radial velocities of component B showed a strong peak at 1.0260 days (Figure 2) and this was adopted to be the orbital period of Ba and Bb. We then used a modified version of the differential-correction program of Barker et al. (1967) to compute a SB-1 orbit for Bab. The elements are listed in Table 1. Note that a circular orbit was finally assumed since the error in e was larger than its optimized value. Figure 2 also shows the radial velocities of the A-component. Its standard deviation is 1.1 km s^{-1} while the B-component's are much larger (4 km s^{-1}).

The photometric data show a marginally significant period of 1.127±0.008 day (Figure 3) which is – formally – not consistent with the 1.082±0.002-day period found by Brettman et al. (1983). Due to the small amplitude of just ≈10 mmag in b and y, and because our time coverage was just two months with one measure per night, we believe that the two periods are still consistent.

The Hipparcos catalog (ESA 1997) lists HR 5 with a parallax of 49.3±0.87 milli-arcseconds corresponding to a distance of 20.28±0.43 pc and with magnitudes in the Hipparcos system of 6.488±0.004 and 7.427±0.009 for the A and B component, respectively. The respective Johnson UBV magnitudes are V(A)=6.352 and V(B)=7.291 mag, which add up to 5.97 mag for the whole A+Ba+Bb system. The magnitude difference

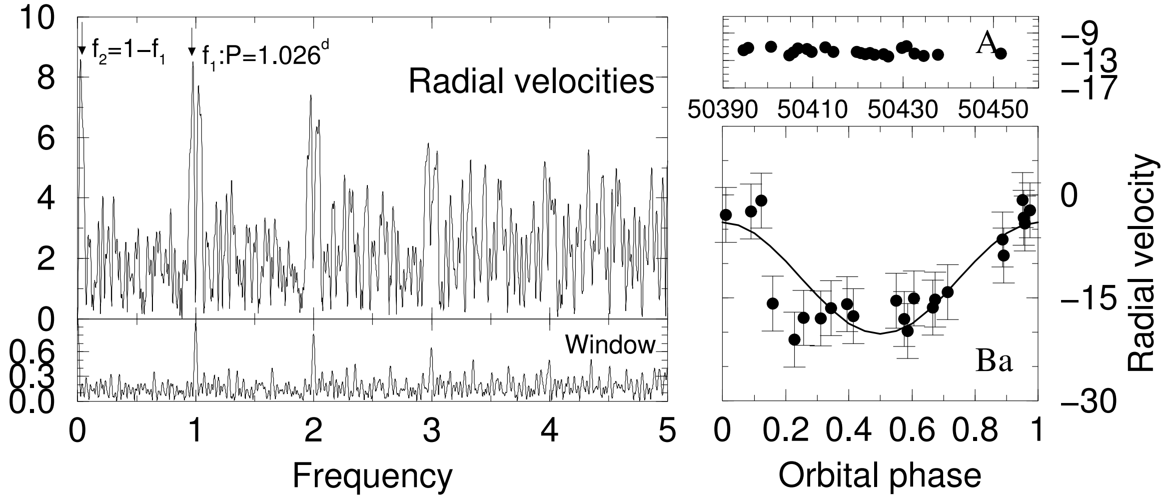

Figure 2. Periodogram and radial-velocity curve for component Ba. The best-fit period is indicated as f_1 (1.026 days) and its $1-f_1$ alias as f_2 (39.5 days). The observed velocities are plotted as dots with error bars, while the line is the orbit from Table 1. Also shown are the radial velocities of component A.

B–A is 0.94 mag, i.e. larger by almost 0.2 mag compared to Wallenquist's (1954) 0.75-mag value from photographic plates. The fact that the photometric period is almost equal to the orbital period of Ba+b (different by just 9%) suggests that the weaker of the two visual components, the Ba component, is the photometric variable. Of course, our photometry contains both visible components but we may subtract the (presumably constant) A-component from the total light and derive the maximum V magnitude for B of $V_{\rm max}$(B)=7.181 mag (transformed from Strömgren y to Johnson V with the relation of Olsen 1983). The corrected amplitude of Ba is then 0.015 mag.

With the new Hipparcos distance, we first obtain absolute magnitudes for the two visual components of M_V(A)=+4.82±0.05 mag and $M_V(\rm Ba + b)$=+5.65±0.05 mag, and also revise the total mass of 2.8±0.6 $M_\odot$ from the visual orbit (Lippincott 1963) to 2.25±0.14 $M_\odot$ (the semi-major axis a is revised to 29.5±0.6 A.U.). According to Gray (1992), the magnitudes match G3V and ≈G8V stars for A and Ba and, in case we neglect interstellar absorption, suggest individual masses of 1.04 $M_\odot$ and ≈0.88 $M_\odot$ and radii of 0.99 $R_\odot$ and 0.87 $R_\odot$, respectively. The relative mass ratio $M_{\rm B}/(M_{\rm A} + M_{\rm B})$ of 0.546±0.006 was computed by Lippincott (1963) from the brightness difference $\Delta m_{\rm pg} = 0.75$ (Wallenquist 1954; note that Wilson (1953) listed a Δm of 0.9). The luminosity ratio $L_{\rm B}/L_{\rm A}$ from the Hipparcos brightness difference of $\Delta m_{\rm Hip} = 0.94$ is ≈0.42 and agrees with the line ratio of 0.69±0.07 (1σ) measured from our red-wavelength spectra corresponding to $\Delta m_{\rm R} = 0.40$ in the R-band.

Finally, with the revised total mass of 2.25 $M_\odot$, we obtain $M_{\rm Ba+b}$=1.23±0.09 $M_\odot$ and $M_{\rm A}$=1.02±0.23 $M_\odot$ for the two visual components. The former value would leave just 0.35 $M_\odot$ for $M_{\rm Bb}$ in case the tabulated mass of a G8-dwarf is used for $M_{\rm Ba}$. The mass function from Table 1 further constrains the minimum Bb mass to $M_{\rm Bb} \sin i$ ≈0.044 $M_\odot$. If we assume that the light-curve variability is due to starspots, which is very likely for a G8-dwarf and was already suggested by Brettman et al. (1983), and thus the photometric period is equal to the rotation period of the Ba component, our measured $v \sin i$ would correspond to a minimum radius for Ba of $R \sin i$(Ba)=0.10±0.04. This would require

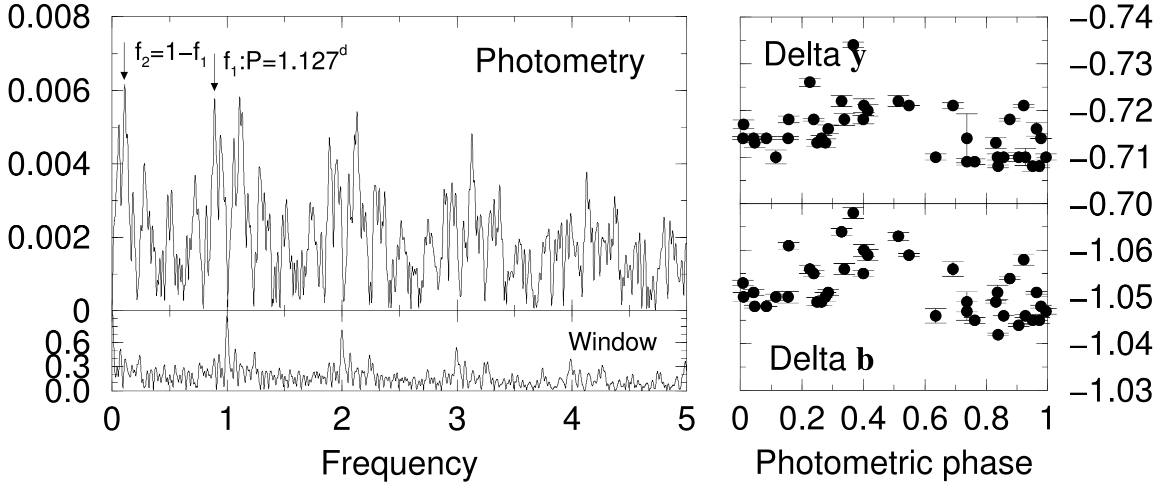

Figure 3. Periodogram and light curves from the Strömgren *by* APT data from Nov.–Jan. 1996/97. A peak at P=1.127 days near the orbital period is seen but is of marginal significance with respect to the average noise level of around 10 mmag. Since the standard error of a single datapoint is just 2.5 mmag for Wolfgang, the large noise level indicates that our sampling did not maintain phase coherence.

the unusual low inclination of the rotation axis of $6.^{\circ}6 \pm 3.^{\circ}5$ to match a typical radius for a late-G dwarf star of $\approx$0.87 $R_{\odot}$. If we further assume that the rotation axis of Ba is perpendicular to the orbital plane of Ba–Bb, the minimum mass for Bb corresponds to $\approx$0.38 $M_{\odot}$, in good agreement with the mass estimated from the visual orbit. The spectral type for Bb is then most likely M2 or M3. Note that the orbital plane of the spectroscopic binary Bab would then be inclined to the orbital plane of the visual components AB by $\approx 40^{\circ}$.

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PHOTOMETRIC INVESTIGATION OF THE NEBULA IN THE AG Peg SYSTEM

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The AG Peg (HD 207 257) system is the oldest known symbiotic nova. Its hot secondary has undergone a single outburst and a high velocity stellar wind has appeared as a result of it. The view this system is at a stage of colliding winds in its evolution is now commonly accepted (Penston & Allen 1985, Kenyon et al. 1993, Tomov 1993, Vogel & Nussbaumer 1994, Altamore & Cassatella 1997). The UV data show that the luminosity and the mass-loss rate of the hot component gradually decrease (Mürset et al. 1991, Kenyon et al. 1993, Vogel & Nussbaumer 1994, Altamore & Cassatella 1997). According to the photometric observations, the visual flux of the system gradually decreases too, although its orbital amplitude remains invariable (Belyakina 1992). In this note we compare two values of the U flux taken in the photometric maximum and separated by four orbital cycles ($\sim 3290^{\mathrm{d}}$). We consider the possible relation between their difference and the variation of the luminosity and the mass-loss rate of the hot component.

Our observations (Table 1) were performed during September 1995 – January 1998 with a single channel photoelectric photometer, mounted at the Cassegrain focus of the 0.6 m F/12.5 telescope of the National Astronomical Observatory Rozhen. We obtained 20 UBV estimates during one orbital cycle (Fig. 1). On JD 2 450 476.2 only B and V estimates were taken. The star BD+11°4681 having $\mathrm{V} = 8\overset{\mathrm{m}}{.}18$, $\mathrm{B-V} = 1\overset{\mathrm{m}}{.}03$ and $\mathrm{U-B} = 0\overset{\mathrm{m}}{.}81$ (Belyakina 1992) was used as a comparison star. The m.s. errors are not larger than $0\overset{\mathrm{m}}{.}01$ in V and B, and $0\overset{\mathrm{m}}{.}02$ in U.

The decrease of the visual light of AG Peg is caused by the decreasing contribution of its circumbinary nebula as the cool component of this system does not change and the hot one has temperature about 90 000 K (Mürset et al. 1991, Kenyon et al. 1993, Altamore & Cassatella 1997) radiating mostly in UV. We will treat the light in the U region where the Balmer continuum of the nebula is radiated and the cool component's spectrum is absent.

The U magnitudes of the AG Peg system on JD 2 446 761.2 (26. Nov, 1986) and JD 2 450 049.3 (27. Nov, 1995) are $8\overset{\mathrm{m}}{.}54$ (Belyakina 1992) and $9\overset{\mathrm{m}}{.}03$ respectively. The corresponding continuum fluxes are equal to 2.84×10^{-12} erg cm^{-2} s^{-1} Å^{-1} and 1.81×10^{-12} erg cm^{-2} s^{-1} Å^{-1} which were corrected for interstellar reddening by means of the value $\mathrm{E(B-V)} = 0.12$ (Penston & Allen 1985) using the extinction law by Seaton (1979). The spectrum of the nebula is formed by the winds of the two stellar components and is ionized by the radiation of the hot secondary beyond the limit of Lyman series. The velocity of the wind of the giant is 20 km s^{-1}, its mass-loss rate is 2×10^{-7} M$_\odot$ yr^{-1} (Vogel

& Nussbaumer 1994, Mürset et al. 1995) and does not vary. Therefore the change of the nebular spectrum is probably due to a change of the hot stellar component and its wind. The radius of this component at the two times considered by us was equal to 0.11 $R_\odot$ and 0.09 $R_\odot$ respectively. These values are arithmetical means of the data of Vogel & Nussbaumer (1994) and Altamore & Cassatella (1997). The second of them was calculated using the value of Vogel & Nussbaumer for the year 1993 as their observations were up to this moment. Thus the Lyman photon luminosity of the hot component was 1.80×10^{46} photons s^{-1} and 1.21×10^{46} photons s^{-1}. The intensity of the nebular continuum is proportional to the ion density. There is, also, linear dependence between the ion density and the density of the radiation field of the ionizing star. In such a case the Lyman photon luminosity will change in the same ratio like the continuum flux at the maximal sensitivity of the U photometric system. It was found that the Lyman luminosity decreasing of 33 % is in agreement with the decreasing of the U flux, which is equal to 36 %.

There is also in the AG Peg system a wind shed by its hot component and its mechanical energy must be considered too. The two winds collide head on, creating a collision region with a small thickness, as described in the very simplified approximation by Girard & Willson (1987). Let us consider every one of these parts of the circumbinary nebula. The hot wind has had a constant velocity of 1000 km s^{-1} (Tomov et al. 1998) during the period treated, but the mass-loss rate of the hot secondary has decreased from 1.48×10^{-7} $M_\odot\,yr^{-1}$ to 7.98×10^{-8} $M_\odot\,yr^{-1}$. These values are arithmetical means of the estimates of Vogel & Nussbaumer (1994) and Altamore & Cassatella (1997). We calculated the continuum flux at the wavelength λ 3650 Å determined by recombinations and free-free transitions in the hot wind for the two moments, considered by us, allowing helium abundance 0.1 and a distance to the system equal to 650 pc (Mürset et al. 1991, Vogel & Nussbaumer 1994, Mürset et al. 1995, Altamore & Cassatella 1997). It turned out that the contribution of this radiation in the U flux of the whole system is negligible and is equal to about 4 % and 2 % respectively. That is why the observed variation of the U flux is not due to the decreasing contribution of the hot wind. In such a case the U light of the AG Peg system probably appears mostly in the collision region of the winds.

Table 1. Photometric observations of AG Peg

JD–2449000	n	V	B	U	JD–2449000	n	V	B	U
974.3	3	8.56	9.76	9.16	1398.2	3	8.85	10.22	10.32
988.4	2	8.55	9.73	9.13	1434.2	1	8.88	10.19	10.21
993.4	2	8.55	9.71	9.09	1476.2	1	8.86	10.18	—
996.4	2	8.58	9.76	9.10	1628.5	3	8.80	10.03	9.75
1012.3	2	8.56	9.75	8.97	1651.5	2	8.74	9.98	9.61
1024.3	2	8.56	9.69	9.08	1698.4	3	8.70	9.89	9.41
1049.3	2	8.56	9.71	9.02	1701.4	2	8.69	9.90	9.42
1092.2	3	8.61	9.76	9.12	1741.2	3	8.69	9.85	9.26
1267.4	2	8.77	10.07	9.95	1742.2	3	8.68	9.84	9.22
1295.4	3	8.75	10.08	10.03	1828.2	2	8.64	9.78	9.13
1297.4	2	8.78	10.08	10.08					

According to the theoretical approximation of Girard & Willson (1987) there are two mechanisms of ionization in this region: radiative one and shock one. The latter of them is determined by the sum of the kinetic energies of the winds. This sum in the two moments under consideration is calculated to be 4.69×10^{34} erg s^{-1} and 2.53×10^{34} erg s^{-1}. It has thus decreased with 46 %, which is also in agreement with the observed decreasing of the U flux.

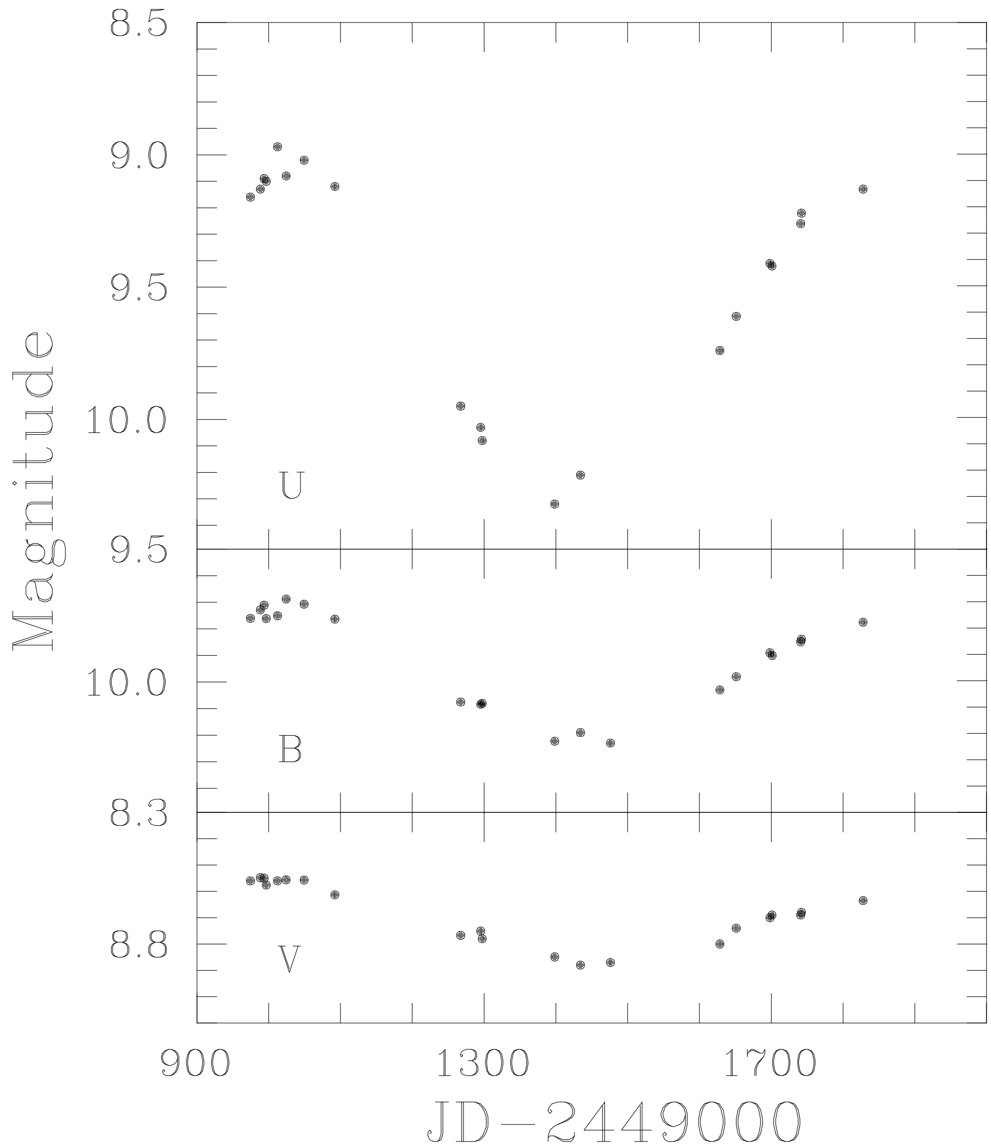

Figure 1. The UBV light curves of AG Peg

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NEW OR UNDESIGNATED VARIABLES

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The Amateur Sky Survey (Droege and Gombert 1998), Dayton, Ohio station, has discovered a number of new variables in Aquila which are not included in the General Catalog of Variable Stars (Kholopov et al., 1985). Table 1 shows positions and magnitudes in Johnson−Cousins V/I photometric bands. Cross-references with the SAO, PPM catalogs and Hubble Guide-Star Catalog (version 1.1) were made where ever possible. Many of these new variables are long-period (or semi-regular) types with V−I magnitudes of >2.0 or more. V and I photometric magnitudes were obtained using all-sky photometry, transformation coefficients are calculated using Landolt standard-stars in the region of −4.5 to −1.5 degrees in declination. Magnitudes transformed to Johnson–Cousins V/I bands have an uncertainty of about ±0.025 magnitude for 8.5−9.0 magnitude stars.

The data was taken with three custom-made CCD cameras using Kodak KAF−0400 chips and 135 mm camera lenses operating in drift-can (Time Delay Integration) mode. More information on the Amateur Sky Survey project can be found on the TASS Home Page maintained by Michael Richmond at the URL http://www.tass-survey.org.

Data was reduced using a suite of photometric programs written by Arne Henden (Henden and Kaitchuck, 1982) of the United States Naval Observatory, Flagstaff station. Light curves and period estimates will be published for these new variables when the analysis has been completed. I am grateful to A. Henden for adapting some of his photometric programs used his equatorial survey project with the Naval Observatories 1 meter FASTT (transit telescope) for use in the Amateur Sky Survey Project.

Table 1

Identifier	RA (J2000) (hh:mm:ss)	Dec(J2000) (d:mm:ss)	V−Range (Max−Min)	I−Range (Max−Min)
GSC 4666:014	00:05:57	−2:41:39	13.03−13.28	11.36−11.74
GSC 4663:915	00:07:07	−2:14:52	14.29−14.67	12.51−13.24
GSC 4667:521	00:15:34	−3:54:36	13.00−13.29	11.31−12.13
GSC 4668:241	00:21:46	−2:40:02	13.61−14.59	12.13−13.08
GSC 4665:391	00:22:25	−2:10:40	13.64−14.70	11.88−12.98
GSC 4672:302	00:33:54	−2:24:41	12.96−13.24	11.35−11.67
GSC 4675:802	00:35:13	−2:55:32	13.86−14.28	12.06−12.91
GSC 4675:758	00:36:30	−4:22:01	12.71−14.06	12.27−12.74
GSC 4675:618	00:37:53	−3:04:36	13.82−14.53	12.05−13.04
GSC 4673:801	00:45:14	−1:56:46	13.84−14.38	12.21−13.33
GSC 4677:585	00:51:13	−4:06:04	14.35−13.46	11.92−12.77
GSC 4682:709	01:19:59	−1:47:39	11.34−11.53	10.09−9.45
GSC 4685:1287	01:44:17	−2:18:42	13.00−14.27	11.61−12.87
GSC 4701:109	02:37:16	−2:53:12	11.75−12.42	6.63−7.19
GSC 4703:103	02:55:42	−2:49:04	12.06−13.03	11.19−11.38
GSC 4711:145	03:15:58	−3:00:37	13.31−14.01	11.57−12.22

Table 1 (cont.)

Identifier	RA (J2000) (hh:mm:ss)	Dec(J2000) (d:mm:ss)	V−Range (Max−Min)	I−Range (Max−Min)
GSC 4719:055	03:35:41	−2:33:52	12.59−13.59	11.88−12.26
GSC 5137:716	19:11:38	−4:25:03	13.01−13.89	8.89−8.47
GSC 5134:2375	19:15:03	−3:18:09	10.89−11.36	6.30−6.67
GSC 5152:1416	19:33:40	−4:13:25	12.55−13.94	10.38−10.62
GSC 5153:2032	19:39:23	−4:24:39	11.42−12.27	7.16−7.71
GSC 5153:1095	19:40:41	−4:04:47	12.69−14.04	10.60−11.51
GSC 5159:664	19:42:53	−2:25:58	11.75−12.17	7.40−7.60
GSC 5151:1336	19:52:57	−3:39:08	11.58−11.95	7.47−7.64
PPM 708160	20:03:04	−2:56:03	10.72−11.11	9.22−9.60
GSC 5180:385	20:03:15	−2:07:13	10.24−10.63	6.26−6.59
GSC 5166:1783	20:17:02	−3:15:38	11.66−12.64	6.86−7.31
GSC 5166:397	20:17:47	−3:00:30	12.50−13.52	12.46−13.52
PPM 708313	20:21:14	−4:12:45	10.18−10.59	6.39−6.67
GSC 5167:1846	20:29:20	−3:20:43	11.16−11.86	9.17−9.42
PPM 708469	20:33:48	−4:02:20	10.18−10.63	8.08−8.26
PPM 708544	20:39:06	−3:59:32	10.31−10.57	7.39−7.46
GSC 1581:2005	20:40:46	−3:14:43	11.84−14.01	12.99−12.29
GSC 5182:006	20:45:38	−2:09:25	13.31−15.04	12.78−13.07
GSC 5182:1726	20:46:15	−3:31:50	11.46−12.33	9.32−9.40
PPM 788711	20:49:25	−2:55:39	10.58−11.03	7.67−7.84
GSC 5182:005	20:51:27	−2:52:38	11.39−11.84	6.89−7.12
GSC 5182:241	20:51:30	−2:31:10	13.68−14.27	12.17−12.37
GSC 5183:1306	20:52:49	−3:25:16	13.14−13.64	11.25−11.76
GSC 5183:1745	20:56:09	−3:31:04	11.27−11.91	7.28−6.86
GSC 5183:464	20:56:50	−2:42:10	11.55−12.36	7.65−7.97
GSC 5183:1745	20:56:59	−3:21:04	11.27−11.91	6.86−7.28
GSC 5196:1584	21:00:29	−3:28:15	12.94−13.31	11.31−11.49
GSC 5196:423	21:03:15	−2:34:39	11.65−11.22	9.62−10.01
GSC 5193:678	21:11:52	−1:45:10	10.87−11.31	7.89−8.13
GSC 5210:184	21:14:35	−3:57:04	12.79−14.53	11.17−11.68
SAO 145250	21:16:08	−1:57:48	9.63−10.11	6.44−6.69
GSC 5199:639	21:22:45	−3:40:11	11.08−11.47	6.24−6.51
GSC 5199:441	21:29:20	−2:14:06	12.06−12.84	8.79−9.21
GSC 5216:162	21:31:44	−3:55:01	12.63−13.02	10.92−11.30
GSC 5219:750	21:57:29	−4:10:20	11.11−12.01	6.64−7.90
GSC 5224:453	22:01:15	−2:14:17	11.81−13.44	11.90−11.34
GSC 5224:474	22:05:11	−1:52:21	13.19−14.54	13.14−11.09
GSC 5236:257	22:32:47	−2:49:10	13.38−14.05	12.15−11.75
GSC 5234:1509	22:40:52	−1:49:11	12.71−13.74	11.35−11.56
GSC 5238:210	22:52:38	−2:31:52	12.71−13.45	11.07−11.58
GSC 5245:290	23:02:25	−2:31:22	12.83−14.36	12.50−13.28
GSC 5246:459	23:13:16	−2:44:11	11.22−12.02	7.06− 7.38
GSC 5258:758	23:40:24	−5:04:07	13.43−14.16	11.80−12.24
GSC 5255:370	23:42:07	−3:05:58	11.85−12.42	10.06−10.91
GSC 5255:365	23:45:18	−4:10:30	13.26−13.80	11.57−12.23
GSC 5252:391	23:47:18	−1:48:30	13.18−13.57	12.89−11.96
GSC 5253:950	23:51:36	−2:20:27	12.66−14.69	12.79−13.03
GSC 5256:315	23:58:41	−3:06:58	13.88−14.52	11.11−11.88
GSC 5256:240	23:59:42	−3:35:11	13.06−13.47	11.53−12.07

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A NEWLY DISCOVERED BY Dra-TYPE STAR: HD 134319

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HD 134319 (G5V; V $\simeq$ +8.42 mag; B−V = +0.68) is a main-sequence G-type star with very strong chromospheric line emissions, most likely arising from strong magnetic activity (Soderblom 1985). High precision radial velocity measures carried out in the CORAVEL program show HD 134319 to have a constant radial velocity $V_r = -6.38 \pm 0.17$ km s^{-1}, indicating that HD 134319 is unlikely a member of a close binary system (Duquennoy et al., 1991). Its U, V, W space velocity components (39, −17, 2 km s^{-1}) are very close to those of the Hyades star cluster (40, −18, −2 km s^{-1}) (Eggen, 1960). This indicates that it is a probable member of the Hyades moving group with an age of about 625 Myr (Perryman et al., 1998).

The photoelectric photometry reported in this paper has been obtained in 1991 with an automatic photometric telescope (APT, see Boyd & Genet 1986) on Mt. Hopkins (AZ/USA): the 0.75m Four Colleges Consortium APT.

The differential photometry of HD 134319 was made in the *u*, *v*, *b* and *y* filters matching the Strömgren system (Strömgren, 1966) and using HD 134851 (K0V; V = +7.1 mag; B−V = +0.90) as the comparison star and HD 138852 (K0III-IV; V = +5.79 mag; B−V = +1.96) as the check star. Ten second integrations were used in each filter and the usual observing sequence of sky-comparison-check-variable-comparison-sky was employed. The measures were corrected for the effects of the atmospheric extinction. No significant light variation was detected from the differential measures of the comparison and check stars, indicating that the light of the comparison stars is constant, within about ± 0.015 mag. Normal points were computed by averaging the observations obtained on each night. The typical standard deviations of the averaged data points are of the order of 0.008 mag in *y* and *b* filters and 0.012 mag in the *v* and *u* filters, because of the lower signal/noise ratio at shorter wavelengths in late-type stars.

The full set of photometric data was analysed using a Scargle-Press period search routine (Scargle, 1982) and a photometric period P = 4.448 ± 0.01 was found. Since the optical flux of HD 134319 changes in amplitude and shape over a scale time of few rotation periods, it proved possible to select two data sets, along which the flux modulation resulted to be rather stable.

Fig. 1 shows the *y*-band, $b-y$, m_1 and c_1 light curves for the mean epochs 1991.18 and 1991.28, respectively. Phases are reckoned from the first observed light curve minimum at HJD = 2448367.766 using the P=4$^{\rm d}\!\!.$448 rotation period.

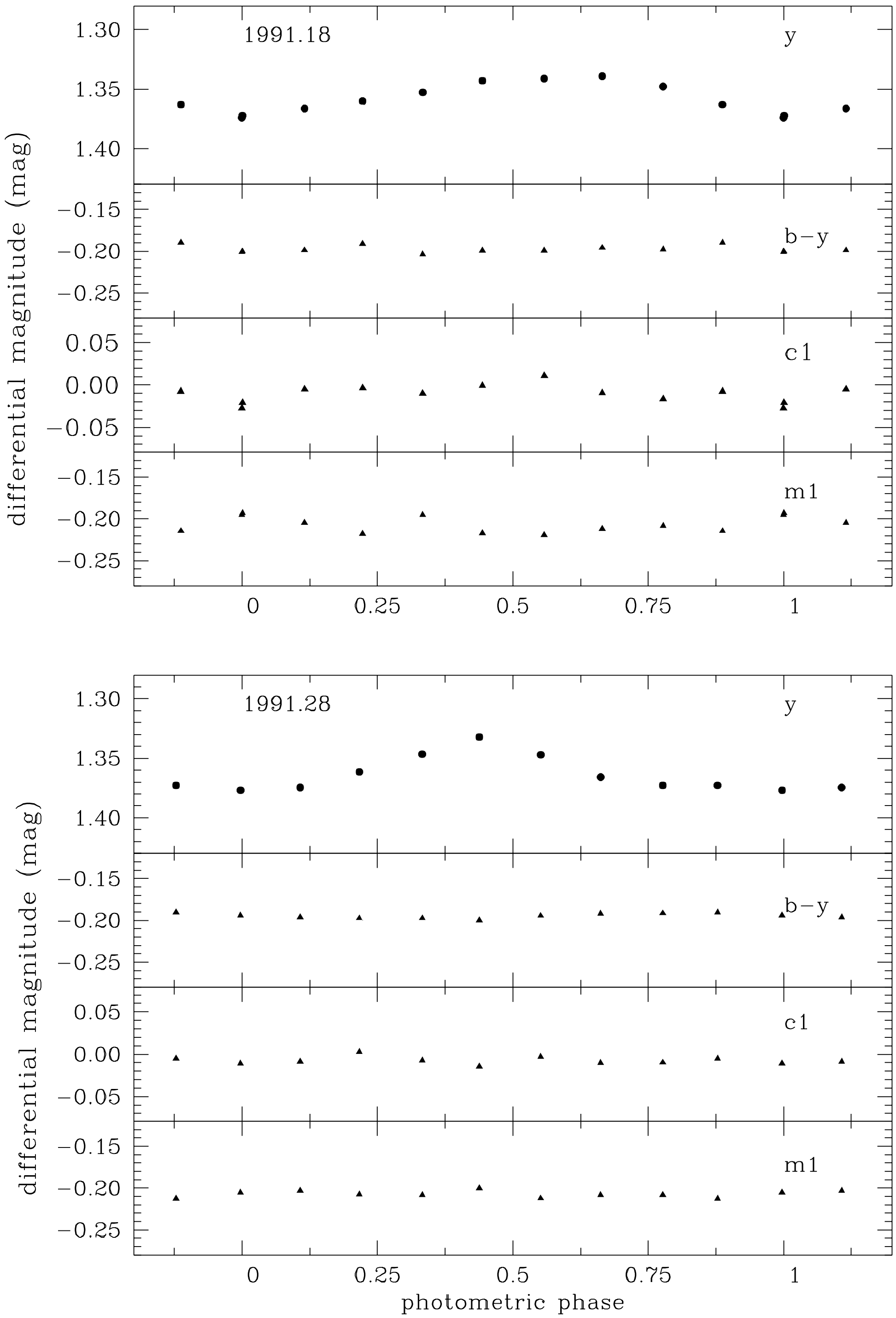

Figure 1. The y-band, $b-y$, c_1 and m_1 light curves of HD 134319 for the mean epoch 1991.18 (*top*) and 1991.28 (*bottom*). Phases are reckoned from the first observed light curve minimum at HJD = 2448367.766 using the $4^{\rm d}_{\cdot}448$ photometric period

Table 1: Mean epochs, number of observing nights, mean differential magnitudes and peak-to-peak amplitude of the light curves of HD 134319 (subscripts v and c denote variable and comparison stars, respectively).

Mean Epoch	# *of* nights	$\langle u_v - u_c \rangle$ (mag)	Δu (mag)	$\langle v_v - v_c \rangle$ (mag)	Δv (mag)	$\langle b_v - b_c \rangle$ (mag)	Δb (mag)	$\langle y_v - y_c \rangle$ (mag)	Δy (mag)
1991.18	14	0.34	0.06	0.75	0.05	1.14	0.03	1.36	0.03
1991.28	17	0.35	0.06	0.76	0.04	1.17	0.05	1.36	0.04

The $4\overset{d}{.}448$ continuum flux modulation is interpreted as arising from the presence of dark starspots, unevenly distributed on the stellar photosphere, whose visibility is modulated by the stellar rotation.

The wavelength dependence shown by the light curves of HD 134319, whose peak-to-peak amplitude increases towards decreasing wavelengths (see Table 1), can be accounted for by the presence of spots cooler than the surrounding photosphere.

Singularity, youth and high level of chromospheric and photospheric magnetic activity make this newly discovered BY Dra-type star a proxy for the young Sun and, therefore, of interest for studying the magnetic activity of the young Sun.

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A NOTE ON THE PERIOD BEHAVIOUR OF BL ERIDANI

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BL Eri (= BD −12°0818, HV 6277; Max: 11.5 mag P, Min: 12.2 mag P) is an eclipsing binary of the W UMa-type which had been neglected for a long time but recently it has attracted attention of observers. Its preliminary light elements based on photographic observations are given in GCVS4:

$$Min.I = JD(hel)\ \ 2429232.082 + 0\overset{\mathrm{d}}{.}4162 \times E \tag{1}$$

First photoelectric photometry of BL Eri was done by Kern and Bookmyer (1986) in December, 1980, and January, 1981. They obtained four times of minimum light and published the improved elements:

$$Min.I = JD(hel)\ \ 2444606.5914 + 0\overset{\mathrm{d}}{.}41696010 \times E \tag{2}$$

Yamasaki et al. (1988) observed this star photoelectrically in November, 1982, and in November, 1986. Their light elements

$$Min.I = JD(hel)\ \ 2444606.5901 + 0\overset{\mathrm{d}}{.}41691339 \times E \tag{3}$$

fitted observations from 1982 (three minima timings) as well as previous times of minima. But observations from 1986 did not agree with these elements so the authors suspected a change (increase) in the orbital period. They calculated other elements which were also suitable for their observations from 1986:

$$Min.I = JD(hel)\ \ 2444606.5880 + 0\overset{\mathrm{d}}{.}41691506 \times E \tag{4}$$

They supposed that the period change occurred within the interval of years 1980-1986.

Quingyao et al. (1994) obtained two photoelectric minima timings and derived the light elements:

$$Min.I = JD(hel)\ \ 2444606.5884 + 0\overset{\mathrm{d}}{.}41691591 \times E \tag{5}$$

Qingyao et al. (1996) confirmed the period increase. Shengbang et al. (1996) on the basis of two new and nine old photoelectric times of minima and the light elements by Kern and Bookmyer (1986) came to the conclusion that the increase in period is continuous and can be described by the following elements with a quadratic term:

$$Min.I = JD(hel)\ \ 2444606.5833 + 0\overset{\mathrm{d}}{.}41691786 \times E + 4\overset{\mathrm{d}}{.}286 \times 10^{-9} \times E^2 \tag{6}$$

Recently, Paschke (1997) analyzed all available times of minima of BL Eri including his nine visual and CCD minima timings and calculated the following linear ephemeris:

$$Min.I = JD(hel)\ \ 2444606.5928 + 0\overset{d}{.}416916 \times E \qquad (7)$$

He agreed with Shengbang et al. (1996) that the O−C values had parabolic course but according to him the increase in period was 20 times slower in comparison to Shengbang's elements. He also noted that five O−C values (Nos 1, 8, 18, 26, and 27 in Table) extremely deviated from the others. They had to be excluded from the data set used for calculation of the elements. All published times of minimum light of BL Eri are listed in Table 1.

Table 1. List of minima timings of BL Eri

No.	JD hel 2400000+	Epoch	O-C	Method	Reference
1	29232.0820	−36877.0	0.1005	pg	Kholopov et al., 1985
2	43515.3150	−2617.5	−0.0002	vis	Locher, 1978a
3	43544.2970	−2548.0	0.0062	vis	Locher, 1978a
4	43749.6310	−2055.5	0.0090	vis	Locher, 1978b
5	43764.6460	−2019.5	0.0151	vis	Locher, 1979
6	43773.6030	−1998.0	0.0084	vis	Locher, 1979
7	43783.6030	−1974.0	0.0024	vis	Locher, 1979
8	43812.5390	−1904.5	−0.0373	vis	Locher, 1979
9	44603.6709	−7.0	−0.0035	pe	Kern, Bookmyer, 1986
10	44604.7146	−4.5	−0.0021	pe	Kern, Bookmyer, 1986
11	44606.5894	0.0	−0.0034	pe	Kern, Bookmyer, 1986
12	44607.6328	2.5	−0.0023	pe	Kern, Bookmyer, 1986
13	45298.8745	1660.5	−0.0073	pe	Yamasaki et al., 1988
14	45299.9170	1663.0	−0.0071	pe	Yamasaki et al., 1988
15	45300.9599	1665.5	−0.0065	pe	Yamasaki et al., 1988
16	47118.4950	6025.0	−0.0167	vis	Paschke, 1988a
17	47141.4400	6080.0	−0.0021	vis	Paschke, 1988a
18	47151.4150	6104.0	−0.0331	vis	Paschke, 1988a
19	47207.3160	6238.0	0.0012	vis	Paschke, 1988b
20	47535.4270	7025.0	−0.0007	vis	Paschke, 1989
21	48286.2900	8826.0	−0.0034	CCD	Paschke, 1991
22	48602.1026	9583.5	−0.0047	pe	Quingyao et al., 1994
23	48603.1452	9586.0	−0.0044	pe	Quingyao et al., 1994
24	48652.3420	9704.0	−0.0037	CCD	Paschke, 1992
25	49698.3920	11213.0	0.0041	CCD	Paschke, 1995
26	50096.6707	13168.5	−0.0804	pe	Shengbang et al., 1996
27	50099.5889	13175.5	−0.0807	pe	Shengbang et al., 1996
28	50114.2715	13210.5	0.0099	CCD	Agerer, Huebscher, 1996
29	50480.3220	14088.5	0.0081	CCD	Paschke, 1997
30	50485.3256	14100.5	0.0087	CCD	Paschke, 1997

Explanations to the table: epochs and O−C residuals were calculated with respect to the elements (7), method of observation is denoted by abbreviations (pg = photographic, vis = visual, pe = classic photoelectric (photomultiplier), CCD = CCD camera).

Remark: minima timings No. 26 and No. 27 have large deviation from the preceding and following ones. The value of this deviation is close to two hours and may have originated from incorrect transformation of local time to universal time. An O−C diagram of BL Eri based on the elements (7) is presented in Figure 1.

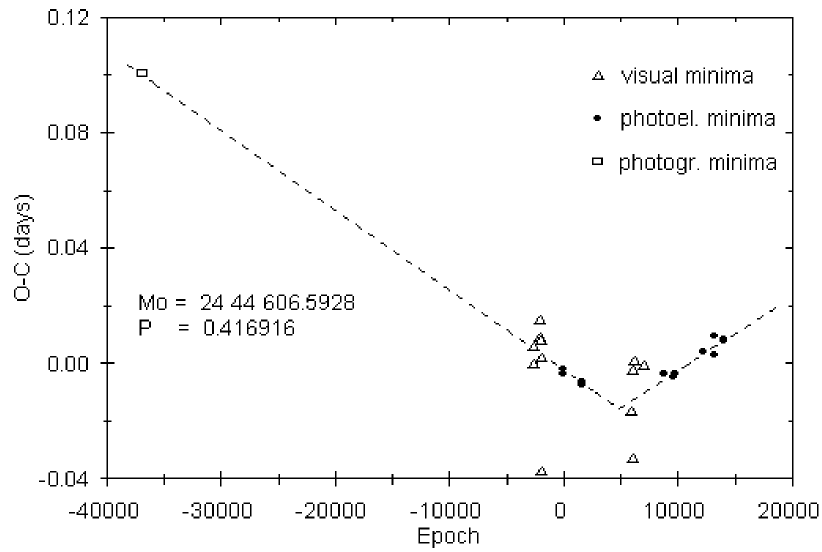

Figure 1. O−C diagram of BL Eri

There is a large gap between the first and the second O−C value but the diagram is sufficient for evaluation of the period behaviour. It can be seen that the general parabolic course suggested by Shengbang et al. (1996) and Paschke (1997) is only a rough approximation. In reality, there is one abrupt period increase by 0.46 second about JD 24 46 622 (July, 1986). Before and after this event the period remained constant. Light elements for the corresponding time intervals are as follows:

$$Min.I = JD(hel)\ \ 2444606.5906 + 0.41691322 \times E \quad (1938 - July, 1986) \tag{8}$$

$$Min.I = JD(hel)\ \ 2448286.2880 + 0.41691855 \times E \quad (afterJuly, 1986) \tag{9}$$

These elements were derived from the minima timings Nos 1-3, 6, 7, 9-16, and Nos 21-30, respectively, with the use of the least squares method. The values No. 26 and No. 27 were corrected by adding two hours.

Now it is clear that the elements (2) have erroneous period value and their use by Shengbang et al. (1996) prevented these authors from finding out that their two minima timings are also in error. The linear elements (4), (5), and (7) contain the period values that represent average values for the two time intervals. They have never been valid. The elements (3) are valid for the interval 1938-1986. For prediction of future minima only the elements (9) should be used.

BL Eri is interesting not only due to its period variation. It exhibits also peculiar variations of the light curve. It belongs among a few W UMa-stars which temporarily have flat (depressed) maxima that resemble rather maxima of close detached binaries than maxima of contact systems (cf. Yamasaki et al., 1988; Quingyao et al., 1994). There are also other signs of non-contact configuration of BL Eri (see e.g. Yamasaki et al., 1988). Yamasaki et al. have shown that the spectral type of BL Eri is approximately G0 IV-V and not B5 as stated in GCVS4. Thus BL Eri may be important from the evolutionary point of view (as a link between detached or semi-detached and contact systems) and the aim of this note is also to support Mr. Paschke's call for further observation of this star.

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Var 61 Her, Var 62 And, KUV 23012+1702: NEW DWARF NOVAE ON MOSCOW PLATES

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Three new UG-type stars (Var 61, Var 62 and KUV 23012+1702) were discovered in the course of the search for new variables on Moscow archive plates. The coordinates of new dwarf novae, taken from the USNO A1.0 catalogue, are presented in Table 1. The finding charts are shown in Figure 1.

Standard sequences SA62 and SA44 (Priser, 1974) were used to obtain B-band magnitudes of comparison stars for Var 61 and Var 62, respectively. Estimates of KUV 23012+1702 were based on the USNO A1.0 catalogue B-band scale. The magnitudes of comparison stars are given in Table 2.

All new variable stars are blue on the Palomar prints.

Table 1. Coordinates of New Variables

Var	α (J2000.0)	δ (J2000.0)
Var 61	$18^h05^m46\overset{s}{.}4$	$+31°40'18''$
Var 62	00 11 07.3	+30 32 36
KUV 23012+1702	23 03 41.8	+17 17 55

Var 61 Her. The star was estimated on 188 plates taken with the equatorial camera in Moscow and the 40-cm astrograph in Crimea for the interval JD 2415288–49634. Seven outbursts have been observed. The new dwarf nova is bright enough, the range of variability on our plates is $13\overset{m}{.}5$–$<18\overset{m}{.}0$. The blue magnitude of the star in the USNO A1.0 catalogue is $19\overset{m}{.}3$, so the amplitude of variability, perhaps, is more than $5\overset{m}{.}8B$. Outbursts (JD24...):

#1	30607.197	< 15.20	#3	37842.490	14.42	#6	43803.254	< 17.00
	30617.214	13.76					43814.217	16.83
	30664.122	< 14.28	#4	40014.488	15.94		43815.196	17.6
#2	34517.389	< 15.20	#5	43045.244	15.20	#7	45230.283	< 17.6
	34534.387	13.53		43047.292	17.6		45232.271	13.56
	34534.405	13.58		43050.290	17.8		45234.249	13.46
							45251.237	< 17.6
							45258.225	18.0

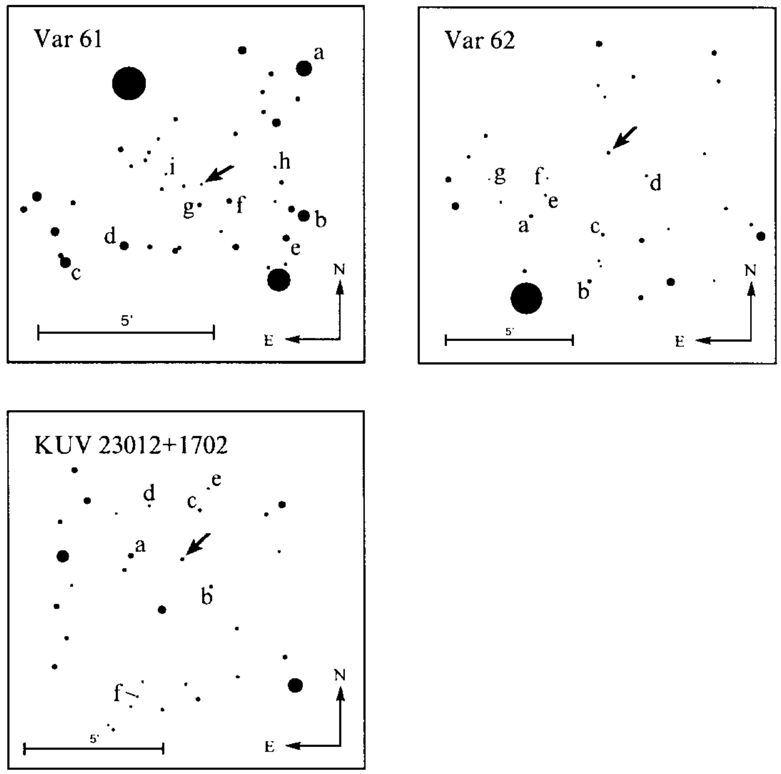

Figure 1. Finding charts

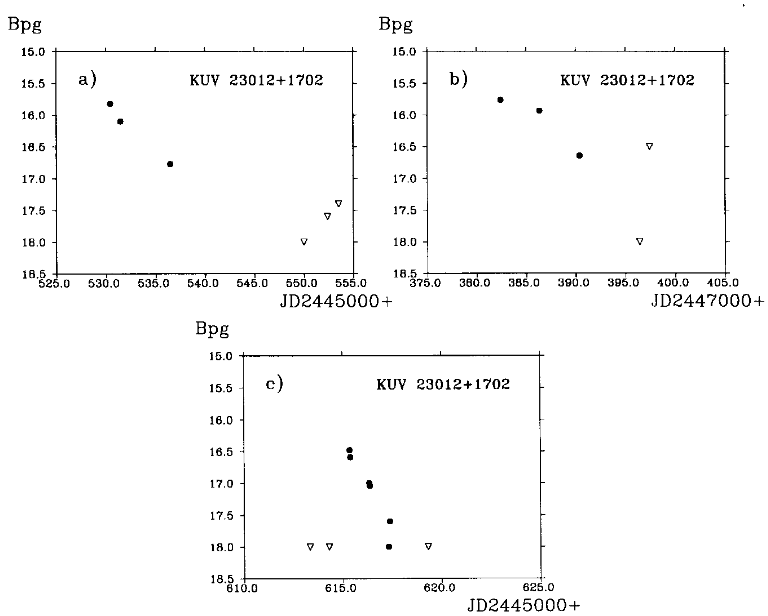

Figure 2. Light curves of KUV 23012+1702: a) and b) bright outbursts; c) faint outburst

Table 2. Comparison Stars

Var	a	b	c	d	e	f	g	h	i
Var 61	13.15	13.63	14.28	15.20	15.65	16.80	17.00	17.6	18.0
Var 62	15.45	15.48	15.97	16.79	17.06	17.54	17.8		
KUV 23012+1702	15.3	16.0	16.5	17.4	17.6	18.0			

Var 62 And. The star was investigated on 102 plates taken with the 40-cm astrograph in Crimea (JD 2445266–47835). Five outbursts have been revealed. The range of variability on our plates is $15^{\rm m}_{\cdot}5$–$<17^{\rm m}_{\cdot}8$. Taking into consideration that, in the USNO A1.0 catalogue, the star is shown at $20^{\rm m}_{\cdot}3B$, we can assume the amplitude of variability exceeding $4^{\rm m}_{\cdot}8B$.

Outbursts (JD24...):

#1	45613.470	16.79	#2	46296.457	< 17.06	#3	47064.427	< 17.8
	45614.380	16.98		46303.488	< 16.79		47086.399	< 15.97
	45615.464	< 17.8		46324.414	15.58		47091.395	15.65
				46325.480	15.55			
				46327.436	15.60	#4	47383.475	16.63
				46329.485	15.87		47389.506	< 17.54
				46330.412	16.46		47396.502	< 17.8
				46331.485	16.38			
				46332.457	> 16.79	#5	47766.570	< 16.79
				46352.499	< 17.06		47773.551	15.45
				46357.357	< 17.8		47793.472	< 17.54

KUV 23012+1702. The star was firstly discovered by Kondo et al. (1984), as a new blue variable object. No classification is given in their work.

I independently discovered variability and estimated this variable on 156 plates taken with the 40-cm astrograph in Crimea (JD2444076–47477). Sixteen outbursts have been revealed. The cycle is (very approximately) 27 days. The range of variability on our plates is $15^{\rm m}_{\cdot}8$–$<18^{\rm m}_{\cdot}0$. It would be interesting to know the brightness in minimum. In the USNO A1.0 catalogue, the object is shown at $18^{\rm m}_{\cdot}2B$, but it is uncertain (because of short cycle) if this really shows the star at minimum light.

The new variable is a good candidate to UGSU-type dwarf novae. Two kinds of outbursts were found: bright ones have $15^{\rm m}_{\cdot}8B$ in maximum and a duration of more than 8 days (Figures 2a and 2b); faint ones have $16^{\rm m}_{\cdot}5B$ in maximum and a duration less than 5 days (Figure 2c).

A CCD spectrum of KUV 23012+1702 was obtained by Wegner and Dupuis (1993). According to their work, the spectral type of this object is sdBe, that does not contradict the suggested classification.

Outbursts (JD24...):

#1	44487.415	16.68	#7	45614.307	< 18.0	#12	46058.219	15.76
	44488.497	16.68		45615.355	16.48			
	44492.409	< 17.6		45615.389	16.59	#13	46289.464	< 17.4
				45616.339	17.00		46293.430	16.68
#2	44852.427	< 17.6		45616.373	17.04		46295.430	< 17.4
	44854.461	17.04		45617.314	18.0			
				45617.376	17.6	#14	46677.439	16.50
#3	45228.475	16.20		45619.310	< 18.0		46679.424	16.91
	45232.444	< 18.0					46681.425	< 18.0
			#8	45642.333	17.13			
#4	45530.443	15.82		45644.278	17.68	#15	47035.492	16.82
	45531.463	16.10		45646.301	< 18.0		47041.485	< 17.6
	45536.497	16.77						
			#9	45695.204	16.00	#16	47382.431	15.76
#5	45553.518	< 17.4					47386.363	15.93
	45558.381	17.27	#10	45936.458	15.79		47390.407	16.64
	45560.494	< 17.4		45943.455	16.82		47396.420	< 18.0
	45562.487	< 18.0		45947.458	< 17.6			
#6	45580.403	17.13	#11	45964.417	< 18.0			
	45581.537	18.0		45965.348	< 17.6			
	45582.499	< 18.0		45972.427	16.73			

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TiO- AND V-BAND PHOTOMETRY OF THE PULSATING RED GIANT V CVn

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V CVn (HD 115898, HIP 65006) is a bright semi-regular red SRa variable star, located on the asymptotic red giant branch. V CVn is interesting because it has properties intermediate between classical Mira variables and Small Amplitude Red Variables (SARVs) as defined by Percy et al. (1996). The study of V CVn by Vetesnik and Papousek (1986) yields a mean photometric period near 192 days, with an average light amplitude of ≈ 1.5 to 2.0 magnitudes. From chiefly AAVSO visual estimates, the visual magnitude of V CVn typically varies from about +6.8 mag to +8.8 mag. The spectral type varies from M4 IIIe to M6 IIIe, and its spectrum is dominated by strong TiO bands (Boyle et al., 1986). Recently the parallax of V CVn has been improved by the Hipparcos satellite to yield a distance as 375 ± 125 pc. Because of the interesting characteristics of V CVn and the lack of detailed multi-wavelength photometry, the star was added to the ongoing program of photometry of cool giants and supergiants at Wasatonic Observatory and Villanova University Observatory. The results presented in this paper represent the first time the radius, luminosity and effective temperature of V CVn have been estimated using narrow to intermediate-band IR photometric techniques. Additionally, observations were made with a filter matched to the Johnson V-band filter at 550 nm.

Photometry was carried out using the Wing near-IR three filter system with filters centered on 719, 754, and 1024 nm, designated as A, B, and C, respectively (Wing, 1992; Morgan et al., 1997). TiO indices, (B−C)-IR color indices, and IR apparent magnitudes are calculated from the observations. The TiO index is calculated from the standardized A, B, and C magnitudes using the following equation adapted from Wing (1992):

$$\text{TiO Index} = \text{A}-\text{B} - 0.13(\text{B}-\text{C}) \tag{1}$$

where B−C is the IR color index. As defined, a numerical increase in the TiO index corresponds to an increase in the TiO absorption at 719nm. In our calibrations of TiO index with spectral type, we find a linear correlation between the index and spectral type up to M8. For stars with spectral types later than M8, the A and B bandpasses become contaminated by molecular absorption bands such as VO and water vapor.

Using a large number of Wing standard stars (Wing, 1978), calibrations were done to establish the difference between observed C-band (1024 nm) magnitudes and calculated bolometric magnitudes using bolometric corrections from Novotny (1973). The observed 1024 nm magnitudes were then transformed to bolometric magnitudes (m_{bol}). Using the Hipparcos parallax, absolute bolometric magnitudes, and hence luminosities, were determined. Also, from Wing (1979) standard star data, IR color index - temperature calibrations were determined, enabling temperatures to be estimated from the observed IR color and TiO indices data. Knowing both luminosities and temperatures, radii were calculated throughout the pulsational cycle by using the equation:

$$(R_\star/R_\odot) = [(L_\star/L_\odot)/(T_\star/T_\odot)^4]^{0.5} \tag{2}$$

Mahler et al. (1997) and Morgan et al. (1997) provide additional details of the Wing 3-color near-IR system, which they used to estimate changing effective temperatures, luminosities, and radii of Mira and Betelgeuse, respectively. These same techniques were used to calculate T_{eff}, $L_\star/L_\odot$ and $R_\star/R_\odot$ for V CVn over its 191.8 day pulsational cycle.

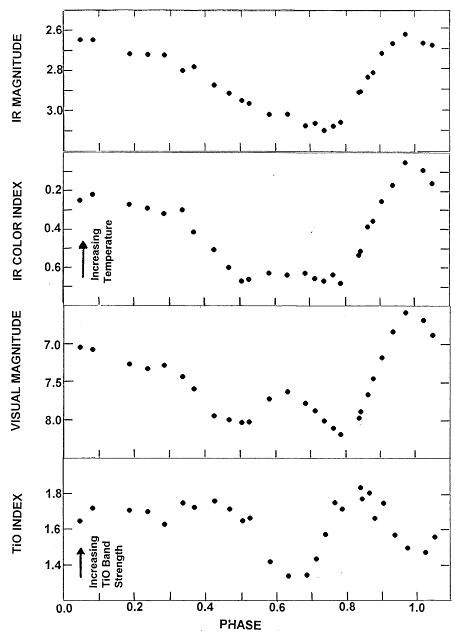

Figure 1. IR (1024 nm) magnitude, (B−C) color index, visual magnitude (550 nm), and TiO index of V CVn during the 1997 observing season

Differential photometry of V CVn was conducted during 1997 on 27 nights from JD 2450462 to JD 2450655 at Wasatonic Observatory. An uncooled SSP-3 Optec photometer, attached to a 20-cm Schmidt-Cassegrain telescope, was used to carry out the photometry. The detector was an uncooled silicon PIN-photodiode. The comparison star was HR 5067 (V = +5.88; B−V = +0.97; K0 III),and the check star was HD 120315 (η UMa, V = +1.86; B−V = −0.19; B3 V). The check star also served as the primary Wing IR standard star, from which all subsequent standardized comparison and variable star IR magnitudes were calculated. All data reductions accounted for atmospheric extinction effects and conversions of UT to HJD. The phases for V CVn were computed using the epoch given in the 1997 Astronomical Almanac, as follows:

$$T_{max} = \text{HJD } 2443929.00 + 191\overset{d}{.}89 \times E \tag{3}$$

Figure 1 shows the various photometric magnitudes and indices found for V CVn, plotted against pulsation phase. The C-band (1024 nm) magnitudes are plotted in the top panel. These data show a nearly smooth quasi-sinusoidal variation with a full amplitude of about δ C = 0.30 mag. Maximum and minimum brightness occur at phase 0.00 and 0.75, respectively. As discussed previously, the behavior of the C-band (1024 nm) magnitude is very similar to the apparent bolometric magnitude (m_{bol}) or the absolute bolometric magnitude (M_{bol}) when scaled with the Hipparcos parallax.

The IR (B$-$C) index is shown in the second panel in Figure 1. Note that this index varies in a similar manner to the C-band (1024 nm) magnitude. The B$-$C values vary from about +0.05 mag at IR maximum brightness to about +0.70 mag during IR light minimum. However, the most positive values of the (B$-$C) index occur over a broad, relatively flat minimum that extends from about phase 0.50 to 0.75. From previous (B$-$C)-T_{eff} calibrations, V CVn attains its maximum temperature of $T_{max} \approx 3200$ K near phase 0.00 and reaches a minimum value of $T_{min} \approx 2200$ K during the 0.50 to 0.75 phase interval. The absolute radius of the star can be found for each ($L_\star/L_\odot$;T_{eff}) data set from equation (2).

In this case, the star attains a maximum radius of $R_{max} \approx 400\ R_\odot$ near light minimum and shrinks to $R_{min} \approx 200\ R_\odot$ at maximum luminosity, when the star is hottest. Table 1 lists the estimated effective temperatures and, in solar units, radii and luminosities of V CVn at phases 0.00 and 0.75, corresponding to the C-band (1024 nm) maximum and minimum magnitudes, respectively.

Table 1. Temperatures, Radii, and Luminosities of V CVn at C-Band (1024nm) Maximum and Minimum Brightness

Phase	C-band mag	Temp.(K)	Radius ($R_\odot$)	Luminosity ($L_\odot$)
0.00	+2.65	3200	200	4600
0.75	+3.10	2200	400	3100

The observed V-band curve is shown in the third panel of Figure 1. It is similar to the light curves of V CVn by Magalhaes et al. (1986) and Kruszewski et al. (1968). Note the secondary maximum or "hump" centered at phase $\approx$ 0.65, which is also a feature in the Kruszewski light curve. As pointed out by Wing (1986), visual light curves for cool stars are strongly dependent on TiO blanketing. The hump in the V-band curve occurs at the same phase where the TiO index decreases, indicating a significant weakening of the TiO absorption. The calculated TiO index is shown in the bottom panel of Figure 1. From TiO - temperature and B$-$C color index calibrations, it was found that the numerical value of the TiO index gives a reliable measure of the TiO line strength out to values of approximately TiO $\approx$ 1.8.

Therefore, the nearly constant value of the TiO index of about +1.7 from phase 0.00 to phase 0.50 is near the limit where the TiO index is useful as a TiO band measure. However, the observed decrease of the TiO index to about +1.35 mag at phase 0.65 is very reliable and indicates TiO dissociation. This normally occurs with an increase in temperature. Note, however, that the temperature, as indicated by the (B$-$C) IR color-index curve (second panel, Figure 1) is relatively constant during this drop in the TiO index. Hence the TiO dissociation at this phase is not due to an increase in temperature, but probably results from other mechanisms. A possible explanation is that a shock wave propagated through the atmosphere, causing the TiO dissociation without producing a significant change in temperature. This could have led to the increase in brightness in the visual magnitude (the hump) at phase 0.65. As the shock dissipated, the TiO index increased from phase 0.65 to 0.80, indicating TiO recombination. This was accompanied by the decrease in the V-band light curve due to the TiO blanketing effect. As shown in the figure, from phase 0.85 to phase 0.00 the TiO index again drops as the star brightens in both the V-band and the C-band (1024 nm). These changes are accompanied by a decrease in the (B$-$C) index, indicative of increasing effective temperature and a dissociation of TiO. The decrease in the TiO line strength causes the drop in the TiO index itself. Data for all four panels of Figure 1 is tabulated in Table 2.

Continued photometry of V CVn is planned. In obtaining more data we hope to ascertain whether the phenomena observed during the 1996/97 observing season reoccurs. The

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Table 2. Plotted V CVn Data

HJD 2450+	Phase	Visual mag	C (1024 nm) mag	Color Index	TiO Index
462.766	0.046	+7.045	+2.649	+0.250	+1.645
469.775	0.082	+7.076	+2.650	+0.219	+1.717
489.626	0.186	+7.266	+2.719	+0.271	+1.707
499.926	0.238	+7.330	+2.723	+0.291	+1.699
508.593	0.285	+7.283	+2.725	+0.319	+1.627
518.604	0.337	+7.433	+2.802	+0.300	+1.748
524.647	0.369	+7.595	+2.783	+0.415	+1.723
535.643	0.426	+7.949	+2.874	+0.507	+1.760
543.553	0.468	+8.001	+2.915	+0.600	+1.714
550.577	0.504	+8.036	+2.951	+0.671	+1.647
554.575	0.525	+8.029	+2.965	+0.662	+1.663
565.576	0.582	+7.725	+3.019	+0.629	+1.418
575.694	0.634	+7.632	+3.018	+0.639	+1.339
585.647	0.686	+7.782	+3.074	+0.629	+1.343
590.590	0.713	+7.880	+3.062	+0.658	+1.433
595.634	0.739	+8.015	+3.097	+0.671	+1.570
600.606	0.765	+8.109	+3.076	+0.638	+1.750
604.607	0.786	+8.192	+3.057	+0.682	+1.714
614.598	0.838	+7.975	+2.908	+0.535	+1.835
615.600	0.843	+7.890	+2.905	+0.514	+1.771
619.610	0.864	+7.668	+2.833	+0.386	+1.805
622.609	0.879	+7.458	+2.811	+0.357	+1.661
627.608	0.905	+7.180	+2.715	+0.254	+1.747
633.602	0.937	+6.838	+2.667	+0.169	+1.567
640.598	0.974	+6.587	+2.670	+0.051	+1.495
650.586	0.025	+6.688	+2.664	+0.091	+1.470
655.573	0.051	+6.882	+2.674	+0.160	+1.556

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Number 4580

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PZ Mon - AN ACTIVE EVOLVED STAR

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PZ Mon is a relatively little studied active K2 star, of recent interest due to discovery of a large amplitude ($\Delta m_{\rm B} \approx 1.0$) spot cycle with a period $P_{\rm cyc} \approx 50$ years (Bondar' 1995). Its spectral type is given as K2Ve by Kukarkin (1958). First noted as a result of its variable optical emission lines (Munch & Munch 1955), PZ Mon was classified a UV Ceti flare star by Petit (1959). Photometric monitoring (Cristaldi & Rodonò 1970, 1973), however, showed that flaring is quite infrequent and typically low amplitude. Longer term brightness variations also suggested it was a BY Dra variable (Wachmann 1968; Bondar' 1992). The star has been detected with *Einstein* (Agarwal et al. 1986) and IUE data (LWP14570L) show a saturated Mg II line.

In the course of a recent study of stellar dynamo cycles (Saar & Brandenburg 1998), we became interested in learning more about the star. Hipparcos data (ESA 1997) give a parallax of $\pi = 0.71 \pm 1.17$ mas, or a distance, $d \approx 1410^{+\infty}_{-880}$ pc. The maximum $m_{\rm pg} \approx 9.8$ and B$-$V = 1.10 (Bondar' 1995) implies $\rm V_{max} \approx 8.8$ (assuming $m_{\rm pg} = \rm B{-}0.11$), consistent with the recent (near maximum) Hipparcos value of V = 9.03. Combining $\rm V_{max}$ and π yields $M_{\rm V} \approx -1.9$ (for $d = 1410$ pc), indicating PZ Mon is clearly not a dwarf; rather, the $M_{\rm V}$ and B$-$V suggest a spectral type of ≈K0 II (e.g., Allen 1973; Gray 1992). The radius R can be expressed as $\log R = \log d - 0.164 - 2\log T_{\rm eff} - 0.2(\rm V + BC)$ (Oranje 1986), yielding $R/R_\odot \approx 45$ for $T_{\rm eff} \approx 4500$ K and $d = 1410$ pc (using the updated bolometric corrections of Flower 1996). The large errors in d, however, mean $M_{\rm V} \approx 0.2$ (for $d = 530$ pc) is also possible, which would make PZ Mon ≈K1 III with $R/R_\odot \approx 17$.

To further explore PZ Mon's evolutionary state and other properties, we obtained high resolution ($\lambda/\Delta\lambda = 125,000$, 2 pixel), moderate S/N (~ 100) spectra of PZ Mon and comparison stars with the stellar echelle spectrograph and TI CCD detector (Smith & Giampapa 1987) at the McMath–Pierce solar telescope of the National Solar Observatory. We used the 10 slice image slicer and the 180 mm transfer lens; the resulting spectra cover a 20Å interval centered near 6170 Å. The data were dark subtracted, flat-fielded, optimally extracted, and wavelength calibrated (using a quadratic fit to six Th-Ar lines).

Fig. 1 shows the PZ Mon data compared with a dwarf of similar color (HD 32147, K4V, B$-$V = 1.06) and a somewhat warmer RS CVn (λ And, G8 III-IV, B$-$V = 1.01). We convolved the HD 32147 ($v \sin i < 1$ km s^{-1}; Saar & Osten 1997) spectrum to $v \sin i = 10$ km s^{-1} with a rotational broadening function ($G(v \sin i)$; e.g., Gray 1992). The λ And spectrum was deconvolved by $G(6.5)$ to correct for its $v \sin i = 6.5$ km s^{-1} (Donati et al. 1995), convolved with $G(10)$, and filtered to suppress deconvolution noise. The wing of the strong 6162Å Ca I line is gravity sensitive, and clearly λ And is a better match near there than HD 32147. Consistent with its higher $T_{\rm eff}$, line strengths in λ And are on average slightly weaker than in PZ Mon. The radial velocity of PZ Mon at the midpoint of observations on HJD 2447834.997 was $v_r = +28.9 \pm 0.3$ km s^{-1}, based on cross-correlation of the spectrum with one of HD 32147 ($v_r = +22.2$ km s^{-1}; Eggen 1992). There is no sign of a secondary star in our spectrum (Fig. 1); if present, it must have a flux <5% of the primary at 6170 Å.

Since PZ Mon is evolved, active, rapidly rotating (for a K giant/bright giant) and spotted, it seems likely to be an RS CVn system. The K1III+? classification (putting $d \sim 500$ pc) is then perhaps slightly preferred, since few RS CVn systems are bright giants (Strassmeier et al. 1993). Further v_r data can help determine whether it is a binary.

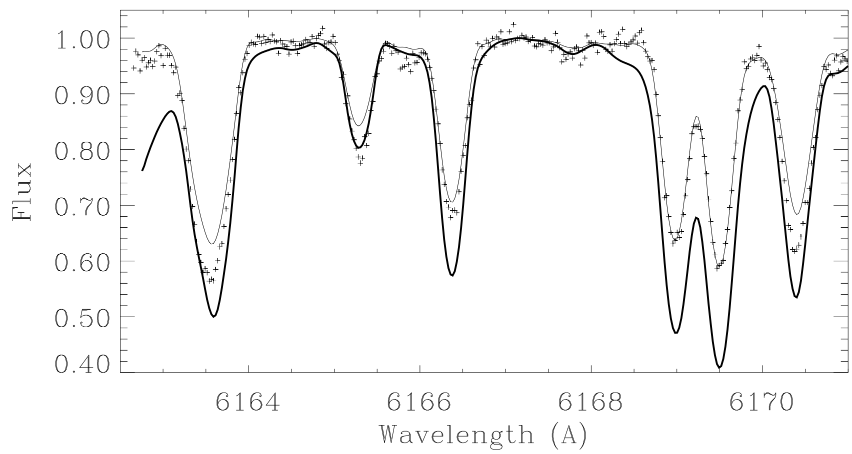

Figure 1. McMath–Pierce data of PZ Mon (+; 0.0245 Å pixel^{-1}, $\lambda/\Delta\lambda = 125,000$, S/N ≈ 100) compared with HD 32147 (K5V; heavy solid) and λ And (G8III-IV; thin solid), both convolved to $v \sin i = 10$ km s^{-1}). All spectra have been shifted to the laboratory λ scale.

Since neither of the comparison stars was a perfect match, we also fit selected line profiles using a simple radiative transfer model (Saar & Osten 1997) to confirm the $v \sin i$. The average results for 4 relatively unblended lines (Fe I 6165, 6180 Å, Ca I 6166 Å, Ni I 6175 Å; Fig. 2) was $v \sin i = 10.2 \pm 0.4$ km s^{-1}, close to results using a comparison star (Fig. 1), and a (radial-tangential) macroturbulent velocity $v_{\rm mac} = 5.5 \pm 0.8$ km s^{-1}. This $v_{\rm mac}$ is normal for a K1 III star ($\langle v_{\rm mac} \rangle \approx 5.0$ km s^{-1}; Gray 1992, his Fig. 18.9), though perhaps slightly enhanced due to activity (Saar & Osten 1997). The magnetically sensitive (Landè $g_{\rm eff} = 2.5$) Fe I 6173Å line is best fit by $v \sin i = 9.9$ km s^{-1} and $v_{\rm mac} = 7.1$ km s^{-1}; the excess broadening in the wings (enhanced $v_{\rm mac}$) suggests the presence of significant magnetic flux (cf. Saar & Linsky 1986).

Agarwal et al. (1986) detected PZ Mon with *Einstein* at 0.021 IPC counts s^{-1}. The star appears to be variable in X-rays: SIMBAD lists a detection at 0.014 IPC counts s^{-1}. Assuming a coronal temperature of 10^7 K and an ISM column of $\log n_H \approx 21.32$ (equal to HD 48279, 1°.4 distant at $d = 1635$ pc; Shull & Van Steenberg 1985), using PIMMS,

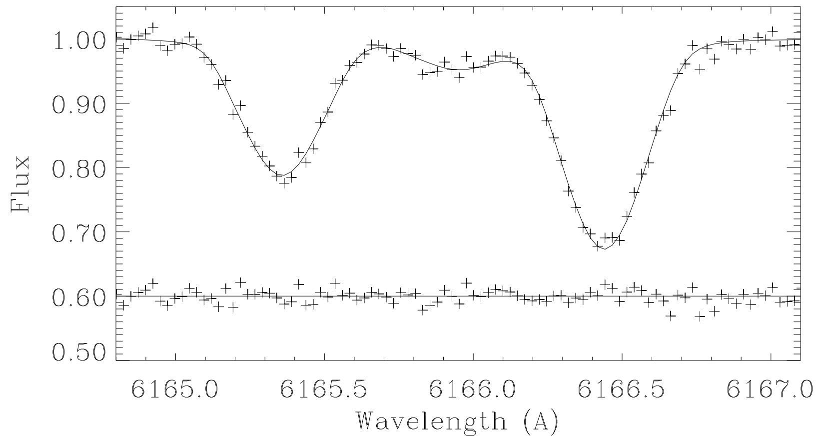

Figure 2. McMath–Pierce data of PZ Mon (+) near the Fe I 6165.3 Å and Ca I 6166.4 Å lines, fit with a simple radiative transfer model (solid), with residuals offset below. Average results for four lines are $v \sin i = 10.2 \pm 0.4$ km s^{-1}, and $v_{\rm mac} = 5.5 \pm 0.8$ km s^{-1}; $\sigma_{\rm fit} = 0.011$.

the Agarwal et al. flux works out to $f_X \approx 5 \times 10^{-13}$ ergs cm^{-2} s^{-1} (0.2-4.0 keV) at earth. Using the calibration of (Oranje 1986), the ratio of surface fluxes (at star/at earth) is $\log F/f \approx 18.3$, implying $\log F_X = 6.0$ ergs cm^{-2} s^{-1} and $\log F_X/F_{\rm bol} = \log L_X/L_{\rm bol} = -4.2$, and $\log L_X = 31.8$ ergs s^{-1} (if $d \approx 1410$ pc) or $\log L_X = 30.9$ ergs s^{-1} (if $d \approx 530$ pc). These values are typical of RS CVn systems (e.g., Dempsey et al. 1993).

The shift of PZ Mon from a dwarf to a giant classification is consistent with its very low level of flaring (RS CVns show few optical flares; Henry & Newsom 1996). It is also consistent with its non-detection by the ROSAT EUVE survey (Tsikoudi & Kellett 1997) – the larger ISM column due to greater d would absorb much of the EUV flux. The combined properties of the star suggest it may be a distant analog to σ Gem (K1III+?, B$-$V = 1.12, $v \sin i = 25$ km s^{-1}, $\log L_X \approx 31.4$; Strassmeier et al. 1993). As PZ Mon is now an active giant, V833 Tau (Hartmann et al. 1981; Bondar' 1995) appears to reclaim the title of the dwarf star with the largest photometric spot cycle amplitude. PZ Mon becomes one of the relatively few evolved stars with a well determined starspot cycle.

In summary, an Hipparcos parallax and new high-resolution spectra show that PZ Mon, long considered a spotted UV Ceti flare star, is actually a distant active giant (probably ~K1III+?) with $v \sin i \approx 10$ km s^{-1} and $v_r = +28.9$ km s^{-1} on HJD 2447834.997. It is likely an RS CVn variable, similar to σ Gem in many respects. The recalibrated X-ray properties of PZ Mon are consistent with RS CVn systems.

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DETECTION OF THE δ SCUTI OSCILLATION IN RZ CASSIOPEIAE

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We have observed the Algol-type binary system RZ Cas (A3V + K0IV) which has been known for the unusual changes of the shape of light curves at the bottom part of the primary minimum (*e.g.* Narusawa *et al.* 1994). We have carried out photometric observations to study "quasi-periodic oscillations"with a period of about 25 min and an amplitude of ± 0.04 magnitude reported by Davis and Balonek (1996) and Davis (1996). Such an oscillation has been found in an earlier time by Olson (1982).

The observations were carried out at four sites as shown in Table 1 with PMT photometers and a CCD camera. The observational journals are summarized in Table 2. In earlier PMT photometry, we used HR 791=HD 17929=HIP 12821 as a comparison star, until we noticed that the variability of this star is described in the Hipparcos/Tycho Catalogue (Perryman, 1997). The catalogued period and amplitude are $1\overset{d}{.}26819$ and $0\overset{m}{.}01$. In the latter observations HD 15784 was used as a comparison star. There is no description of the variability in the HD 15784 in the Hipparcos/Tycho Catalogue. Even though in the earlier observations, there should be no serious problem to use HR 791 as a comparison star, because we studied the variability on the time scale of 0.01 - 0.02 d which is very short compared with that of the variability for HR 719. In the CCD photometry, we use SAO12413=Tyc4316-00097-1 and HD 16615=HIP 12734 as the comparison and the check star respectively. There are no descriptions of variability on these stars in Hipparcos/Tycho catalogue.

In our all observational data obtained on the photometric nights, we have detected the periodic oscillations with the amplitude of twenty mmag. In Fig. 1, the oscillation in RZ Cas at a primary minimum in B-band, a secondary minimum in R-band and an out-of-eclipse in B-band are shown. All light curves indicated here are corrected for the mean light curves. The correction is performed in the intensity scale. In the primary minimum, in order to separate the short-term variability from the light variation caused by the eclipse, we subtract the mean light curve from observed light curve. The mean light curve we used is the 4th order polynomial fitted by the least-squares method to the date produced by folding the observations at the minimum.

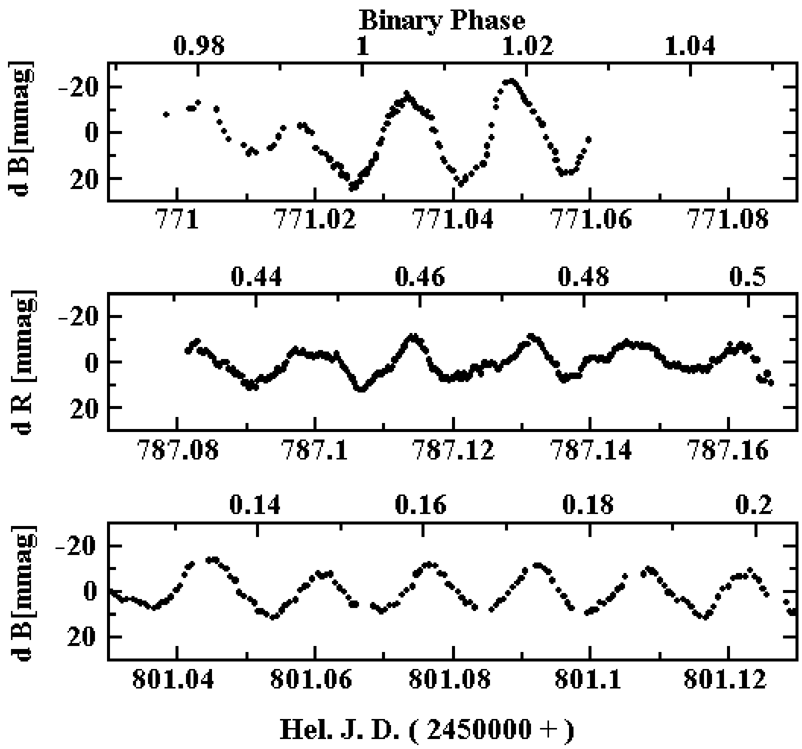

Figure 1. Observed oscillations at various binary phases of RZ Cas. Upper, middle and lower light curves obtained at a primary minimum in B-band, a secondary minimum in R-band and an out-of-eclipse in B-band respectively

We adapted the PDM analysis (Widjaya, 1996) to B-band photometric data with a time span of 83 days. In Fig. 2, the relative variance of data set, theta, is illustrated in the upper subfigure. The periodicity is found at the period of 0.0155766 (frequency = $64^{\mathrm{d}}.199^{-1}$) and $0^{\mathrm{d}}.0157812$ ($63^{\mathrm{d}}.367^{-1}$) with multi-periodic feature. The detailed analysis of light curve should be performed more carefully. In the lower subfigure, the five-point running averaged magnitudes are plotted with the phase. Since the spectral type of the primary is A3V, we can see the star is in the bluest group of known δ Scuti stars and also included in the theoretical instability strip for the δ Scuti stars (*e.g.* see Moskalik 1995). The period of $0^{\mathrm{d}}.016$ is not typical one of the δ Scuti stars, but is not too short because the periods of the shortest known δ Scuti stars are $0^{\mathrm{d}}.0205$ and $0^{\mathrm{d}}.03$ for V624 Tau and V377 Cas, besides $0^{\mathrm{d}}.0084$ for a suspected member of the group V816 Cen. We conclude that the oscillations in RZ Cas we detected are the δ Scuti variability and that RZ Cas may be the shortest period star in the known δ Scuti stars. The relation between amplitude and color variations in the oscillation of RZ Cas shown in Fig. 11 of Olson (1982) justly indicates the character of the δ Scuti oscillation.

We suppose that the temporal changes of the shape of light curves during the primary

Table 1: Observational Sites

Site	Observer	Telescope[1]	Detector[2]	Integ. Time
Funao	Akazawa	0.28-m S.C.	PMT R647p P.C.	10 sec.
Senoh	Ohkura	0.35-m S.C.	PMT R647p P.C.	10 sec.
BAO	Kawabata	1.01-m Cass.	PMT R647p P.C.	10 sec.
FBO	Fujii	0.075-m refractor	CCD ST-7	10/20 sec.

[1] S. C. : Schmidt-Cassegrain telescope
[2] P. C. : photon-counting system

Table 2: Observational Log

Start time (Hel. J. D.)	Binary Phase Coverage	Band	Comparison Star	Site
2450747.100	0.981 - 0.026	B,V	HR791	Funao
2450753.054	0.963 - 0.016	B,V	HR791	Senoh
2450753.093	0.995 - 0.010	B,V	HR791	Funao
2450753.264	0.139 - 0.196	B,V	HR791	Funao
2450759.055	0.984 - 0.015	B,V	HR791	Senoh
2450759.077	0.002 - 0.021	B,V	HR791	Funao
2450770.997	0.975 - 0.029	B,V	HR791	Senoh
2450771.008	0.985 - 0.015	R	HD12413	FBO
2450771.024	0.998 - 0.026	B,V	HR791	Funao
2450776.987	0.986 - 0.024	B,V	HR791	Funao
2450776.992	0.991 - 0.022	B,V	HR791	Senoh
2450786.163	0.663 - 0.721	B,V	HR791	Senoh
2450787.078	0.429 - 0.502	R	HD12413	FBO
2450788.042	0.235 - 0.244	B,V	HD15784	Funao
2450788.078	0.266 - 0.321	B,V	HD15784	Senoh
2450793.038	0.415 - 0.510	B,V	HD15784	Funao
2450793.047	0.423 - 0.518	B,V	HD15784	Senoh
2450800.945	0.031 - 0.281	R	HD12413	FBO
2450801.048	0.117 - 0.230	B,V	HD15784	Funao
2450801.055	0.123 - 0.181	V	HD15784	BAO
2450805.998	0.259 - 0.319	B,V	HD15784	Funao
2450806.025	0.281 - 0.366	B,V	HD15784	Senoh
2450807.024	0.117 - 0.217	B,V	HD15784	Senoh
2450808.000	0.934 - 0.011	B,V	HD15784	Funao
2450808.005	0.937 - 0.060	U,B,V	HD15784	Senoh
2450825.975	0.972 - 0.033	B,V	HD15784	Senoh
2450829.970	0.392 - 0.374	B,V	HD15784	Funao
2450830.063	0.314 - 0.515	B,V	HD15784	Senoh

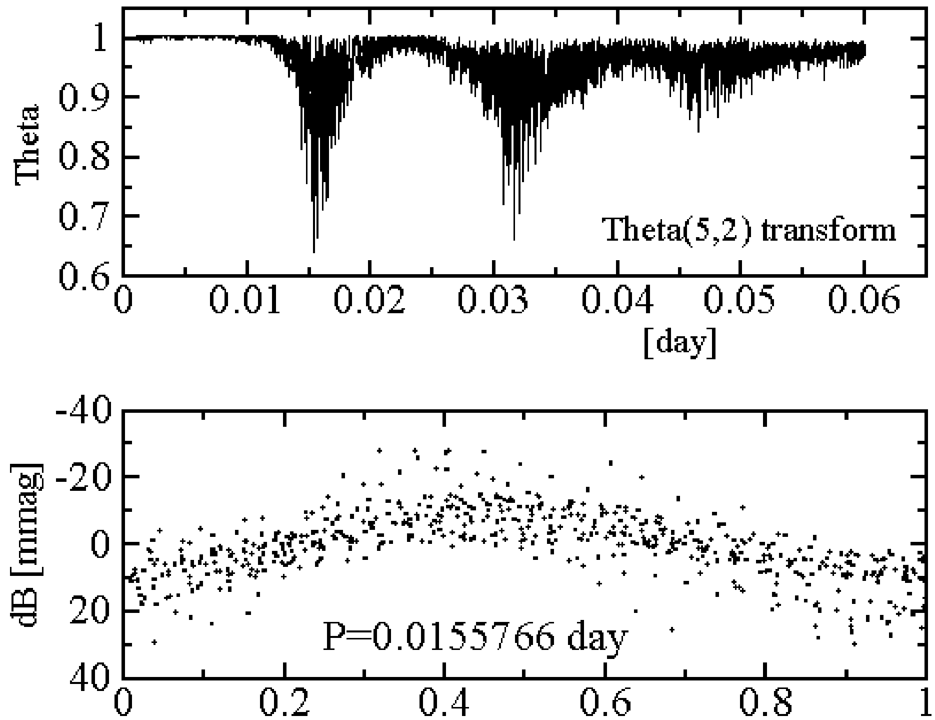

Figure 2. a) The relative variance, Theta, for all B-band observations derived from the PDM analysis. The periodicity is found at 0.0155766 and 0.ᵈ0157812 with multi-periodic feature. b) The five-point running mean values plotted with one of the most dominant period, 0.ᵈ00155766

minima were caused from the superposition of the delta Scuti type oscillation of the A3 component. Detailed analysis of the light curve will be published elsewhere.

We express our gratitude to Prof. Mine Takeuti and Dr. Tosihito Ishida for their useful discussion on the Delta Scuti oscillations, and to Dr. Taichi Kato for his critical advice. We also appreciate the encouragement of Prof. Atsuma Yamasaki and Prof. Yasuhisa Nakamura to our observations. One of the authors (S. N.) thanks to Dr. W. Osborn of Central Michigan University for his kindly sending the paper of Davis (1996).

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Budapest
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REPORT ON NEW OBSERVATIONS OF NSV 06391

ENRIQUE GARCIA-MELENDO

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e-mail: duranobs@astro.gea.cesca.es

Name of the object:
NSV 06391 = GSC 4402.0018 = BV 0352 = CSV007077

Equatorial coordinates:	**Equinox:**
R.A.= $13^{\mathrm{h}}40^{\mathrm{m}}26\overset{\mathrm{s}}{.}6$ **DEC.=** $+67^{\circ}56'3''\!.6$	2000.0

Observatory and telescope:
Esteve Duran Observatory; 0.6-m Cassegrain

Detector:	CCD Camera
Filter(s):	V
Comparison star(s):	GSC 4402.0129
Check star(s):	GSC 4402.0020
Transformed to a standard system:	No

Availability of the data:
URL: http://www.konkoly.hu/pub/ibvs/4501/4582-t1.txt

Type of variability:	RRab

Remarks:
Ephemeris: Max. = HJD2450843.4494 + $0\overset{\mathrm{d}}{.}503760 \times E$ $\pm 0.0003 \pm 0.000004$ Variability discovered by Geyer (1960).

References:

Geyer, E., 1960, *Bamb Ver.*, **5**, N. 9
Kholopov, P.N., editor, 1982, New Catalogue of Suspected Variable Stars, Moscow

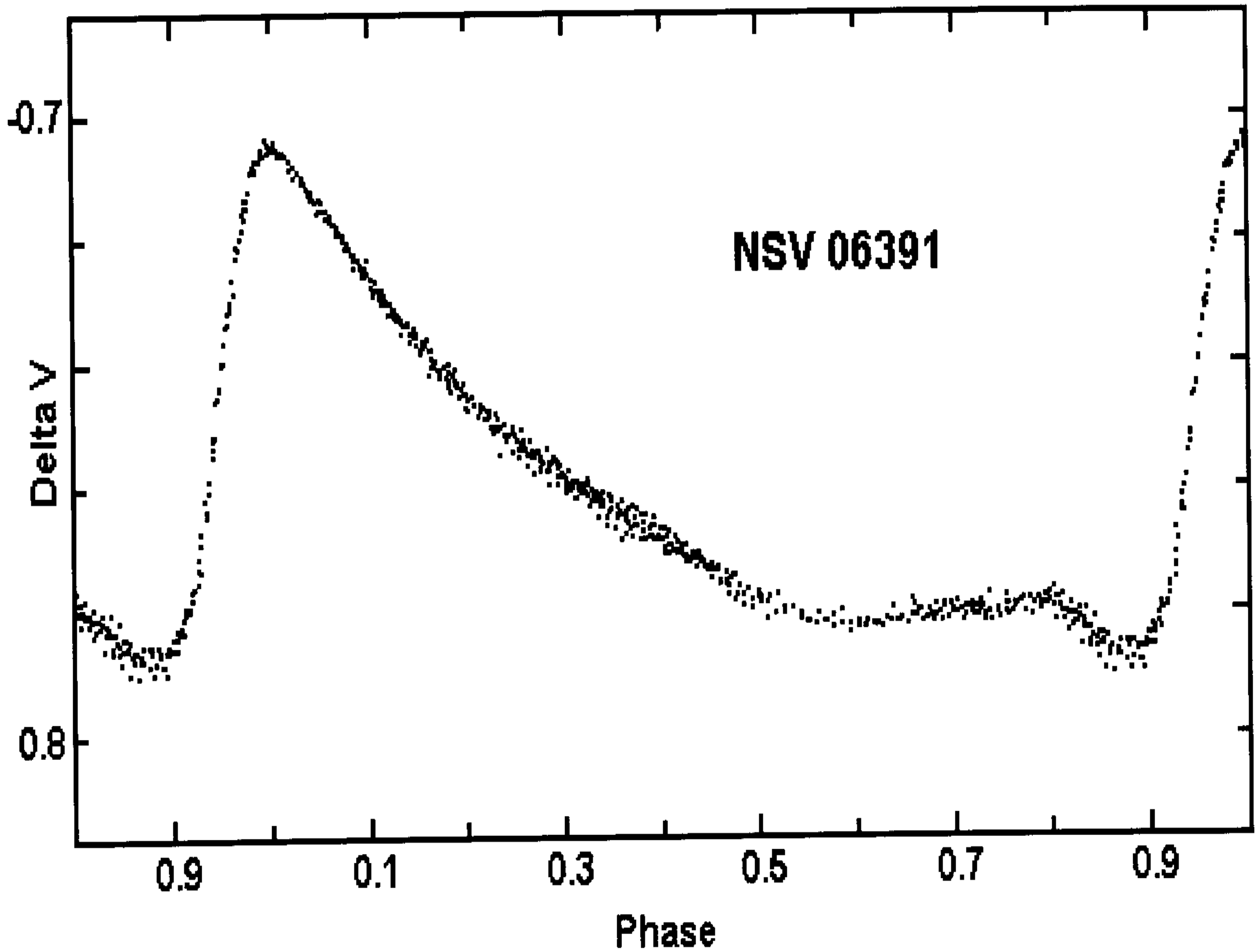

Figure 1.

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REPORT ON NEW OBSERVATIONS OF NSV 03881

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Name of the object:
NSV 03881 = GSC 4540.2590 = CSV 001189

Equatorial coordinates:	**Equinox:**
R.A.= $08^h07^m35\overset{s}{.}4$ **DEC.=** $+76°24'54\overset{''}{.}07$	2000.0

Observatory and telescope:
Esteve Duran Observatory, 0.6-m Cassegrain telescope

Detector:	CCD Camera
Filter(s):	No filters were used
Comparison star(s):	GSC 4540.2396
Check star(s):	GSC 4540.2678
Transformed to a standard system:	No

Availability of the data:
URL: http://www.konkoly.hu/pub/ibvs/4501/4583-t1.txt

Type of variability:	RRab

Remarks:
Ephemeris: Max. = HJD 2450489.5954 + $0\overset{d}{.}615 \times$ E $\pm$ 0.0011 $\pm$0.002 The variability of the object was discovered by Baker (1937 and 1938).

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Kholopov, P.N., editor, 1982, New Catalogue of Suspected Variable Stars, Moscow

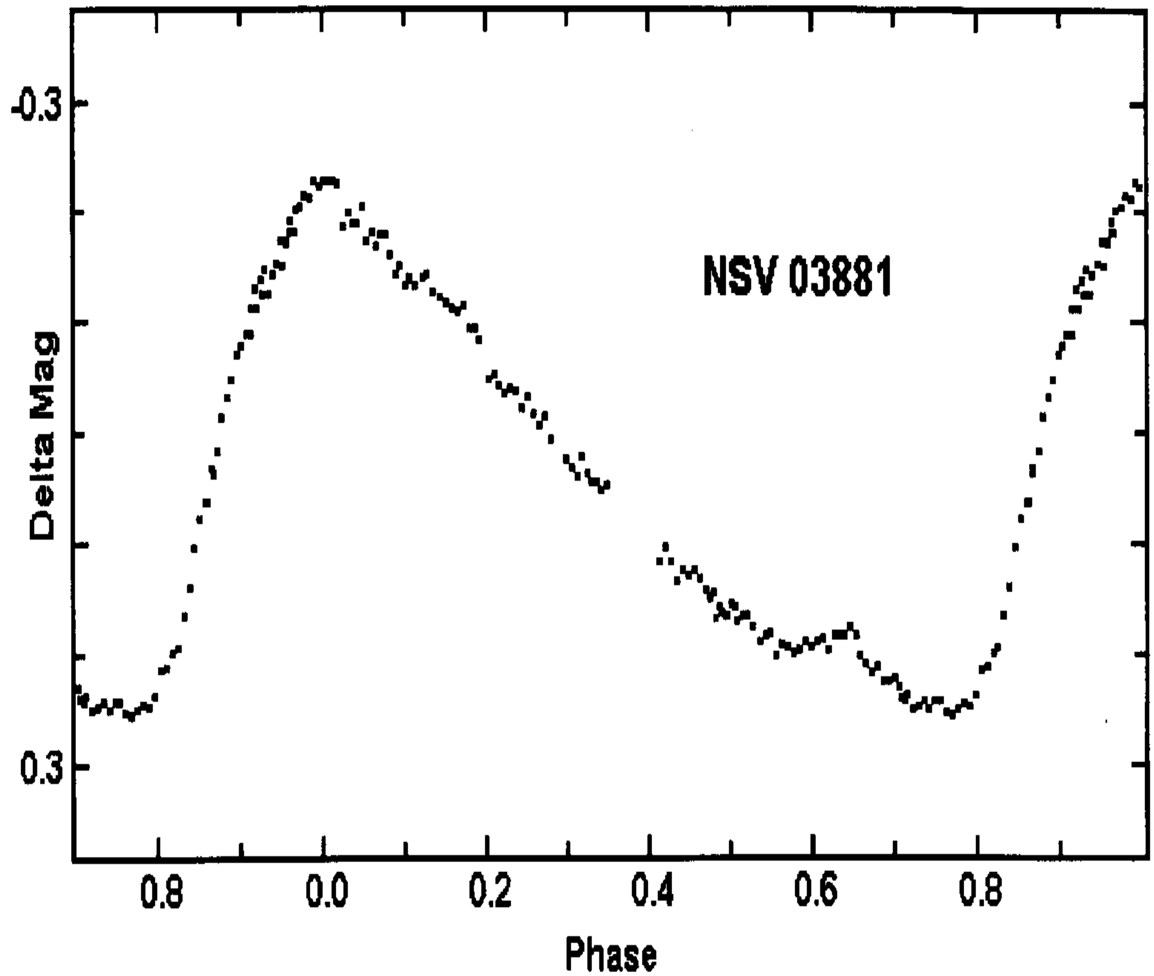

Figure 1.

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ON IDENTIFICATIONS OF SEVERAL VARIABLE STARS IN CYGNUS

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In the earlier practice of variable-star research, lack of sufficient attention to accurate coordinates created a number of problem cases even when discoverers presented quite accurate coordinates in their original announcements. In this paper, we present a solution of a problem case for several variable stars in Cygnus as it is accepted now by the GCVS team, based upon detailed discussions with T. Kato (Kyoto University, Japan), J. Manek (Stefanik Observatory, Czech Republic), and R. Webbink (University of Illinois, USA).

Baade (1928) announced his discovery of a number of new variable stars. He did not publish finding charts but presented rather accurate coordinates for the equinox 1925.0. Among stars designated in the Namelist (NL) No. 31 (Guthnick and Prager, 1933), there were Baade's variables OX Cyg (108.1928), OY Cyg (76.1928), and PR Cyg (70.1928).

OX Cyg. Baade's coordinates ($19^h52^m0\overset{s}{.}6$, $+39°3'9''$, 1925.0) clearly correspond, in the USNO A1.0 catalog, to a star at $19^h54^m39\overset{s}{.}46$, $+39°14'59\overset{''}{.}2$, 2000.0 (USNO A1.0 blue magnitude: $16\overset{m}{.}1$; red magnitude: $14\overset{m}{.}7$). The discoverer attributed the star to eclipsing variables (NL No.31 calls it a short-period variable); the variability of the A1.0 star has been confirmed by J. Manek (private communication) on Sonneberg plates, with probable Algol-like changes. As it will be shown below, all other information published for 'OX Cyg' actually refers to OY Cyg.

OY Cyg. Baade's coordinates ($19^h52^m5\overset{s}{.}2$, $+39°6'6''$, 1925.0) correspond to GSC 3137.1152 ($12\overset{m}{.}9$; $19^h54^m43\overset{s}{.}86$, $+39°17'58\overset{''}{.}2$, 2000.0). For unclear reasons, NL No. 31 gives declination different by approximately 25′; the GCVS accepted the NL coordinates, having in mind that the NL contains a reference to a letter from Baade concerning his new variables. Baade considered his star a Mira (in the NL, an irregular variable).

Nassau and van Albada (1949) identified OY Cyg with the red giant 23–30; their paper contains good photographic charts for program stars. The star 23–30 is actually in approximately $1\overset{'}{.}5$ from the NL position. The photometry presented by Nassau and van Albada shows only marginal evidence for variability.

Hoffleit (1975) published a detailed study of a large-amplitude variable, probably a symbiotic one, called OX Cyg in her paper. She presented a finding chart. The star, later included into catalogs of symbiotics and into programs of amateur groups, is definitely GSC 3137.1152. Note that, for OX Cyg, both references in the GCVS (4th edition) are to Hoffleit (1975).

PR Cyg. Baade's star, classified as an irregular variable, has coordinates $19^{\mathrm{h}}52^{\mathrm{m}}59\overset{\mathrm{s}}{.}9$, $+38^{\circ}4'5''$, 1925.0. It is identical with GSC 3137.1721 ($13\overset{\mathrm{m}}{.}3$; $19^{\mathrm{h}}55^{\mathrm{m}}41\overset{\mathrm{s}}{.}23$, $+38^{\circ}16'3\overset{''}{.}9$, 2000.0). Nassau and van Albada (1949) identified it with their red giant 24–40 and presented several photographic and infrared measurements, again with only marginal evidence for variability. They stated, however, that their photographic data show PR Cyg as much as $1\overset{\mathrm{m}}{.}7$ fainter than the catalog value. The USNO A1.0 coordinates of 24–40 are: $19^{\mathrm{h}}56^{\mathrm{m}}11\overset{\mathrm{s}}{.}20$, $+38^{\circ}15'52\overset{''}{.}7$ (2000.0), about $0\overset{\mathrm{m}}{.}5$ in right ascension and $0\overset{'}{.}2$ in declination from Baade's position. The star's magnitudes in the A1.0 catalog are: $18\overset{\mathrm{m}}{.}3$ (blue) and $15\overset{\mathrm{m}}{.}3$ (red). Baade's coordinates correspond, however, to Nassau and van Albada's star 24–39.

Decision taken by the GCVS team. We accept the following identifications to be used in future:

OX Cyg = Baade's original 108.1928. (Type EA:).

OY Cyg = Baade's original 76.1928 = Hoffleit's 'OX Cyg' = IRAS 19529+3910 = GSC 3137.1152. Not identical with Nassau and van Albada's 23–30. (Type ZAND:).

PR Cyg = Baade's original 70.1928 = Nassau and van Albada's 24–39 = GSC 3137.1721. (Type LB).

Nassau and van Albada's stars 23–30 and 24–40 are to be considered suspected variables; they will enter one of the future catalogs of suspects (supplementing the NSV catalog).

Versions of the GCSV with corrections regularly introduced can be retrieved from the GCVS home page (http://zeus.sai.msu.su/groups/cluster/gcvs/gcvs/).

The authors are grateful to T. Kato, J. Manek, and R. Webbink for attracting our attention to the case and many useful suggestions and discussions. Our work on the catalogs of variable stars is partially supported by the Russian Foundation for Basic Research (grant 97-02-16739) and by the State Program "Astronomy" of Russian Federation.

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Nassau, J.J., van Albada, G.B., 1949, *Astrophys. J.*, **109**, 391

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REDISCOVERY OF THE LOST DWARF NOVA V893 Sco

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V893 Sco (=SVS 1772) was discovered by Satyvoldiev (1972a). Petrov and Satyvoldiev (1975) reported photoelectric photometry giving V=13.0 and B−V=+1.0 for this star. Satyvoldiev (1982) further published its light curve, which is reminiscent of that of a dwarf nova, characterized by occasional brightenings of a few magnitudes.

Despite several investigators' efforts in identifying V893 Sco, the variable has remained lost. For example, "A Catalog and Atlas of Cataclysmic Variables – 2nd Edition" (Downes et al. 1997) states "field unidentifiable from the chart (Satyvoldiev 1972a); possible large error in position". Rediscovery attempts by visual observations and literature searches (vsnet-chat messages) have been unsuccessful. The reference to Yao Bao-an et al. (1980) in the GCVS is wrong (Skiff, 1997); the paper cited contains no study of the star.

K. Haseda, however, while checking patrol films taken with a twin 10cm F4.0 astrograph and Kodak T-Max 400 films, noticed a variable star near the location of the designated position of V893 Sco. The discovery observations are given in Table 1. The magnitudes were determined against neighbouring GSC stars.

Table 1. Rediscovery observations of V893 Sco by Haseda

Year	Month	Date (UT)	mag.
1998	January	28.852	13.0
	February	1.843	12.5
		26.835	15.2
	March	1.817	15.2
		5.806	15.2

Noting that Haseda's position, $16^{h}15^{m}14\overset{s}{.}9$, $-28^{\circ}37'35''$(J2000.0), closely coincides with a ROSAT bright source RXS 161516.2-283712, we have suspected the identity of Haseda's star with the "lost" V893 Sco. Examination on Haseda's film has confirmed the identity of the object with the USNO A1.0 star (USNO 0600.11409621) at $16^{h}15^{m}15^{s}.15$, $-28°37'30''.1$ (J2000.0).

Following this discovery report and the suggestion of identification with V893 Sco, E. Kazarovets examined Moscow plate archive, which Satyvoldiev (1982) used as a part of constructing his light curve, rediscovered the variable, and found a good agreement of the bright epochs of the variable with those given by Satyvoldiev (1982). Upon the authors' request, V. Satyvoldiev, S. Ibadov, and B. Irkaev compared Haseda's finding chart with Satyvoldiev's photographs of V893 Sco, and they definitely confirmed the two objects are identical. Figure 1 shows the finding chart of V893 Sco drawn from USNO A1.0.

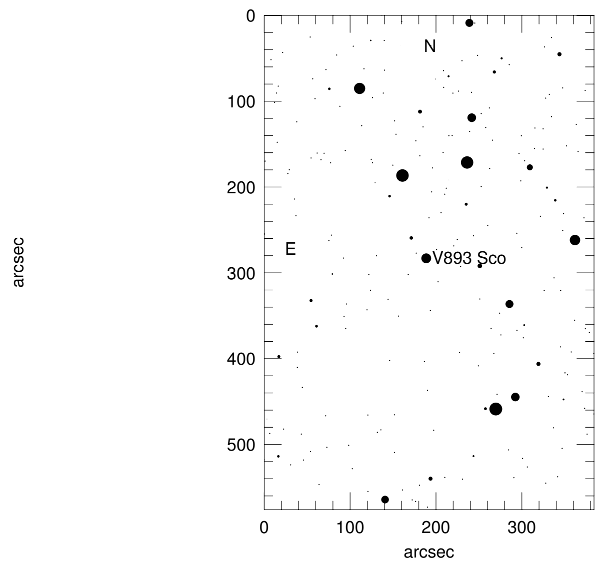

Figure 1. Finding chart of V893 Sco drawn from USNO A1.0

The seeming discordance in the original finding chart (Satyvoldiev 1972a) has been also solved. The chart given for V893 Sco = SVS 1772 (noted as V3 in Satyvoldiev 1972a) is actually identical with the chart for NSV 07698 = SVS 1794 (noted No. 18 in Satyvoldiev 1972b). The latter variable and the field can be reasonably identified on this chart, giving an identification with GSC 6794.410.

The authors (E. V. K. and N. N. S.) would like to thank the Russian Foundation for Basic Research (grant 97-02-16739) for partial financial support of the GCVS work.

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IZ AURIGAE

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The variable star IZ Aurigae = S 8006 = GSC 3373.518 (α_{J2000} : $05^{\mathrm{h}}53^{\mathrm{m}}36^{\mathrm{s}}$; δ_{J2000} : $+52°25'57''$) was discovered by Hoffmeister (1963). He gave remarks on the type (EA) and range of variability ($13 - 14m_{pg}$) as well as on the fact that he had observed only one certain minimum. A bibliographical search in the SIMBAD data base did not yield any other information on this star.

We have observed IZ Aur with an SBIG ST-6 CCD camera attached to the 0.35 m S-C-telescope of the R. Szafraniec Observatory at Metzerlen, Switzerland. GSC 3373.732 (GSC magnitude: 11.17) served as comparison star C, while GSC 3373.454 was used as check star K. Both these stars turned out to be constant at the $0\overset{\mathrm{m}}{.}01$ level ($C - K = -1.00 \pm 0.01$ in the instrumental system). A total of 99 CCD measurements (without using a filter) during 15 nights from JD 2450844 to JD 2450902 have been obtained. In addition, 55 CCD (without filter) observations were gathered by E. Blättler (private communication) with a SBIG ST-7 at his 0.15 m refractor in a private observatory located at Wald, Switzerland, yielding photometry at the $0\overset{\mathrm{m}}{.}03$ level. His observations were obtained during two nights (JD 2450864, JD 2450871) and cover the phase interval $0\overset{\mathrm{P}}{.}3$ to $0\overset{\mathrm{P}}{.}6$. Due to the proximity of the comparison stars to the variable, no correction for differential extinction was applied to the data.

We have subjected the 154 observations to a period search routine. Together with a well observed time of primary minimum, the following elements are found:

$$\mathrm{JD}(min, hel) = 2450846.2735(7) + 0.771301(5) \times E \qquad (1)$$

In Figure 1, we show all our CCD data folded with the elements (1).

IZ Aurigae is an Algol type eclipsing binary with a deep primary minimum (amplitude in the instrumental system: $1\overset{\mathrm{m}}{.}56$; duration of eclipse: $D = 0\overset{\mathrm{P}}{.}23 \pm 0\overset{\mathrm{P}}{.}01 = 0\overset{\mathrm{d}}{.}17 \pm 0\overset{\mathrm{d}}{.}01$; no observable phase of totality) and a well defined secondary minimum of $0\overset{\mathrm{m}}{.}39$ depth and of equal duration as the primary. This secondary occurs at phase $0\overset{\mathrm{P}}{.}5$. We therefore conclude that IZ Aurigae is a detached binary with a circular orbit.

From the depth of the two minima we can infer that the inclination of the orbit is very close to 90° and that IZ Aur consists of two stars of about equal radius but considerably different luminosity and hence colour. This system seems to be rather interesting concerning the possibility of determining accurate physical properties.

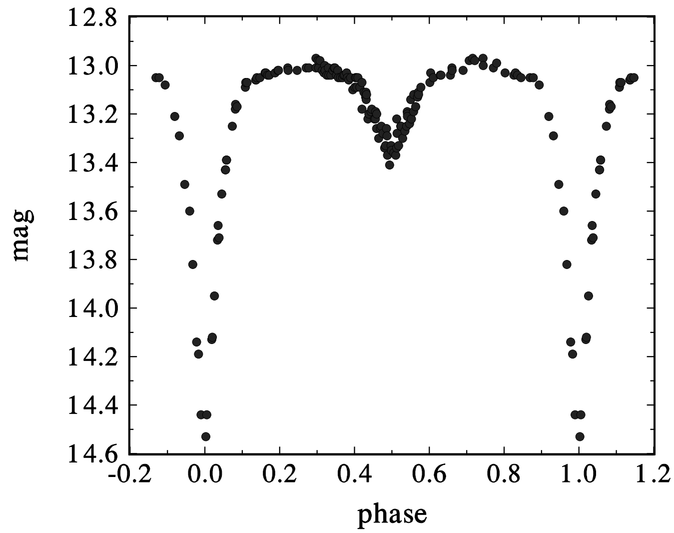

Figure 1. CCD light curve of IZ Aurigae using the elements (1)

This research made use of the SIMBAD data base operated by the CDS, Strasbourg, France.

Reference:

Hoffmeister, C., 1963, *Astr. Nachr.*, **287**, 14

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REVISED ELEMENTS AND CCD LIGHT CURVE FOR AU DRACONIS

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The variability of AU Draconis = BV 53 = GSC 4421.2005 ($\alpha_{J2000}: 17^{\rm h}35^{\rm m}21^{\rm s}; \delta_{J2000}: +68°38'18''$) was reported by Geyer et al. (1955). From photographic photometry, Tsessevitch (1956) deduced the elements

$$\mathrm{JD}(min, hel) = 2435635.397 + 0.51514 \times E \tag{1}$$

with an EA type light curve. Tsessevitch's elements are given in the GCVS (Kholopov et al., 1985). The elements (1) are based on observations obtained within a short time span (85 days), yielding a rather uncertain value for the period. The only other source of information on AU Draconis consists of a few visually determined minima by Czech observers (Borovička et al., 1992).

We have observed this neglected star with an SBIG ST-7 camera attached to the 0.15 m refractor of our private observatory located at Wald, Switzerland. GSC 4421.1750 (GSC magnitude: 13.10) served as comparison star. This setup yields photometry at the $0\overset{\rm m}{.}04$ level. A total of 215 CCD measurements (without a filter) during 7 nights from JD 2450770 to JD 2450902 have been obtained. Due to the proximity of the comparison star to AU Dra, no correction for differential extinction was applied to the data.

The elements (1) are not suitable for representing our observations adequately. We therefore subjected our data to a period searching routine. The best period value of P = $0\overset{\rm d}{.}515267$ resulted from this study. Although the published times of minimum cover only three very small sections in time with large gaps in between and the cycle count numbers cannot be determined with certainty, all the known minima can be represented within the errors of the data by elements using a period value virtually identical to the one found with the period search routine, namely

$$\mathrm{JD}(min, hel) = 2450770.3112(10) + 0.51526673(13) \times E. \tag{2}$$

In Figure 1, we show all our CCD data folded with the elements (2). The O$-$C values for the available times of minimum are given in Table 1, where the earlier timings from photographic and visual photometry have been reduced to seasonal mean values.

AU Draconis shows the light curve of a close binary of the EB type with some asymmetry in both minima. The primary minimum is $0\overset{\rm m}{.}7$ deep ($11\overset{\rm m}{.}3$ - $12\overset{\rm m}{.}0$) while the secondary has an amplitude of $0\overset{\rm m}{.}3$. The secondary occurs at phase $0\overset{\rm P}{.}5$.

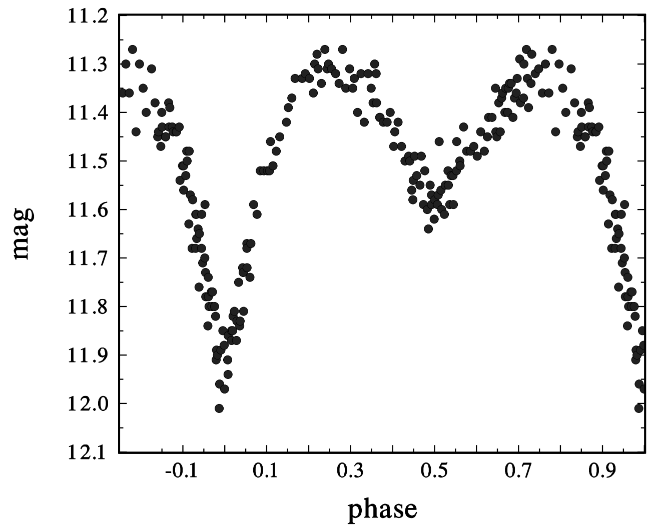

Figure 1. CCD light curve (without filter) of AU Dra folded with the elements (2)

Table 1. O−C values of the observed minima of AU Dra based on the elements (2)

JD(hel)	e.e.	E	O−C	Mode	Reference
2435699.275		−29249.0	0.000	pg	Tsessevitch (1956)
2447706.536	0.003	−5946.0	+0.001	vis	Borovička et al. (1992)
2450599.496	0.005	−331.5	−0.004	CCD	Diethelm (1998)
2450710.284	0.002	−116.5	+0.001	CCD	Blättler (1998)
2450770.311	0.003	0.0	0.000	CCD	Blättler (1998)
2450774.434	0.002	8.0	+0.001	CCD	Blättler (1998)
2450778.297	0.002	15.5	−0.001	CCD	Blättler (1998)
2450822.3520	0.0011	101.0	−0.0011	CCD	Blättler (1998)
2450823.6397	0.0002	103.5	−0.0016	CCD	Blättler (1998)

This research made use of the SIMBAD data base operated by the CDS, Strasbourg, France.

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RECENT OUTBURST OF AG Dra HAS FINISHED

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The symbiotic star AG Draconis is a binary with the orbital period of 554 days (Meinunger 1979). It consists of a red giant of the spectral type <KIII (Kenyon and Fernandez-Castro 1987) with a mass of 1.5 $M_\odot$ and a white dwarf with the effective temperature of $T_{eff} = 1.2\times10^5$ K and the mass of 0.5 $M_\odot$. Garcia (1986) found an orbital separation of 400 $R_\odot$. Huang, Friedjung and Zhou (1994) confirmed that the cool component is a yellow star and is therefore less cool than most cool components of symbiotic binaries. AG Draconis has been very intensively monitored symbiotic star since 1890 photographically (Robinson 1966) and since 1965 photoelectrically as well. Until 1930, its light curve (LC) displayed a quiescent stage, but there have been observed several outbursts afterwards (1936, 1951, 1966, 1980, 1985, 1994) with the maximum amplitude of around 4 magnitudes.

We have intensively monitored this star in the last years, especially from 1994, when the last series of eruptions begun (Petrík and Hric 1994).

The photoelectric observational material discussed in this paper was obtained in the interval between July 12, 1994 and February 17, 1998, at the Hlohovec, Skalnaté Pleso and Stará Lesná Observatories (Cassegrain 600/7500, single-channel photometer with digital converter). The moments of the individual observations and U, B, V magnitudes are listed in Table 1. The accuracy of the photoelectric observations did not exceed 0.03 mag (U) and 0.02 mag (B, V). The star BD + 67°925 having V=9.88 mag, B−V=0.56 mag and U−B=−0.04 mag (Skopal and Chochol 1994) was used as a comparison.

Photoelectric data, which were not obtained by us, were collected in the frame of the international photometric campaign of symbiotic stars (Hric et al. 1996 and references therein) and were adopted from Meinunger (1979), Kaler (1987), Iijima et al. (1987), Petrík and Hric (1994), Montagni et al. (1996), Mikolajewski (1997), Greiner et al. (1997) and Tomova and Tomov (1998). Historical light curves (LCs) for the system of AG Draconis are presented in Figure 1.

Many authors studied the problem of periodicities in this system and number of them (Meinunger 1979, Iijima 1987, Skopal 1994, Bastian 1998) had proposed the ephemeris for the basic orbital period or for the outburst occurrence. Unfortunately, except of some notes about the shorter, but not determined exactly, time intervals between the outburst's peaks, there was no rigorous period analysis performed for this system. Bastian (1998) has used the visual data provided by the AFOEV observers to determine the basic period in the whole set of data, spanning around 20 years. He found P = 380 days as the period of outbursts. Nevertheless, there are longer intervals between some outbursts (> 380 days), not covered by any increase of visual brightness (cf. Fig. 1 in Bastian 1998).

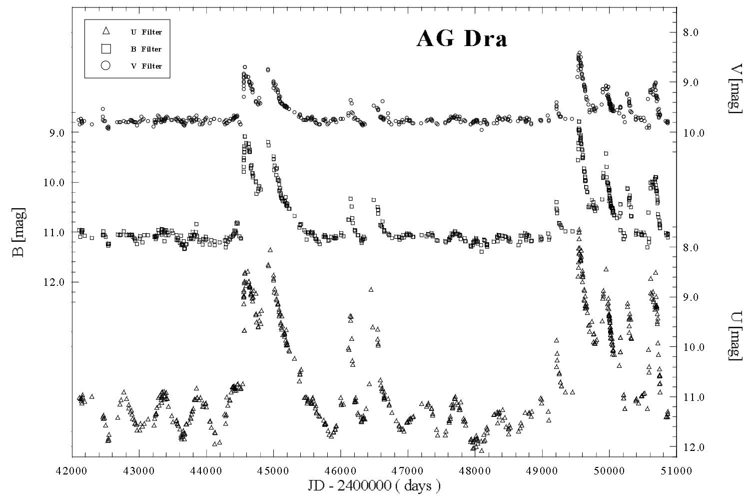

Figure 1. Historical light curves of AG Draconis in U, B and V colours

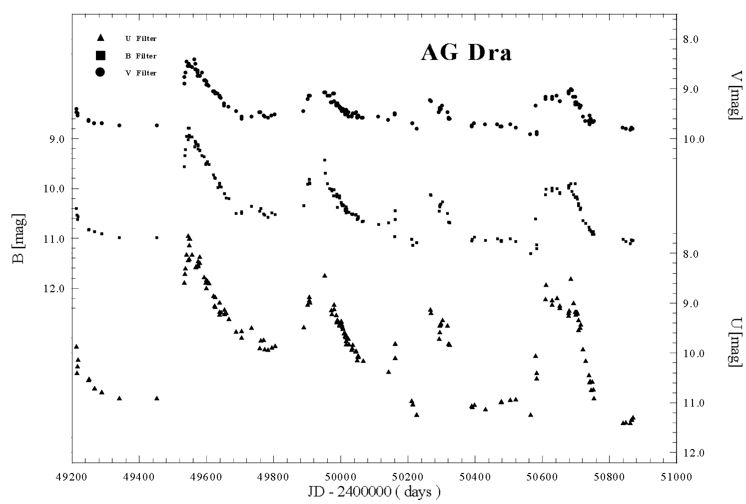

Figure 2. Recent outburst period of AG Draconis captured from August, 1993 to February, 1998

Our historical LCs cover roughly the same time interval as in Bastian (1998) and contain photoelectric photometry from the literature above. The wave-like variations are clearly visible in all colours, interrupted from time to time by the active phase. Each such active phase contains several outbursts. (1980-1981, 1985-1986, 1994-1997).

That's why we decided to divide all data to active and quiet stages and analyze them separately for the possible periodicities. Fourier period analysis revealed two significant groups of periods, each one characteristic for different stage of AG Dra. Table 2 shows the exactly obtained periods for each colour and the stage of this symbiotic/recurrent nova.

Table 1: Photoelectric observations of AG Draconis

JD_{hel} $-2\,400\,000$	U	B	V	ΔR	Obs	JD_{hel} $-2\,400\,000$	U	B	V	ΔR	Obs
49266.494	10.73	10.87	9.69	-	SP	49987.343	9.37	10.15	9.35	−1.00	SP
49288.400	10.81	10.92	9.70	-	SP	49989.371	-	10.38	9.29	-	HL
49545.55	7.92	9.00	8.55	-	HL	49989.377	9.36	10.17	9.30	−1.04	SP
49548.46	-	8.93	8.52	-	HL	49996.640	9.46	10.15	9.36	−1.04	SP
49549.45	7.66	8.79	8.55	-	HL	50001.400	9.39	10.29	9.40	-	HL
49549.51	7.72	8.95	8.51	-	HL	50001.423	9.37	10.28	9.39	-	SL
49550.45	7.84	9.09	8.50	-	HL	50002.361	9.44	10.32	9.43	-	SL
49550.47	7.60	8.84	8.57	-	HL	50004.396	9.48	10.34	9.45	-	SL
49550.46	7.72	8.97	8.54	-	HL	50005.633	9.52	10.32	9.43	−1.00	SP
49556.516	8.05	8.97	8.58	−1.50	SP	50006.596	9.54	10.33	9.40	−1.02	SP
49574.41	8.24	9.14	8.66	-	HL	50008.634	9.62	10.35	9.44	−0.99	SP
49574.430	8.18	9.14	8.63	-	HL	50013.370	9.68	10.45	9.51	-	SL
49574.476	8.27	9.12	8.67	−1.44	SP	50013.401	-	10.43	9.45	-	HL
49575.405	8.27	9.21	8.75	−1.40	SP	50014.655	9.70	10.44	9.52	−0.90	SP
49579.428	8.21	9.23	8.75	-	SL	50015.317	9.78	10.44	9.47	-	HL
49580.36	8.09	9.24	8.75	-	HL	50015.331	9.78	10.44	9.47	-	HL
49592.528	8.50	9.37	8.84	−1.32	SP	50015.536	9.67	10.37	9.43	−1.02	SP
49597.49	8.60	9.52	8.84	-	HL	50016.308	9.67	10.42	9.48	−0.97	SP
49600.31	8.50	9.61	8.97	-	HL	50016.366	9.84	10.49	9.44	-	HL
49600.498	8.55	9.50	8.92	−1.26	SP	50017.462	9.70	10.41	9.45	−0.95	SP
49602.517	8.58	9.46	8.92	−1.26	SP	50018.439	9.71	10.46	9.57	-	SL
49608.30	8.62	9.52	8.95	−1.22	SP	50022.413	9.73	10.81	9.47	-	HL
49620.610	8.87	9.72	9.05	−1.16	SP	50031.578	9.96	10.52	9.56	-	SP
49626.559	8.89	9.79	9.09	−1.13	SP	50034.637	9.92	10.53	9.53	−0.91	SP
49638.538	9.00	9.90	9.16	-	SP	50035.662	9.85	10.51	9.50	−0.93	SP
49653.43	9.23	10.10	9.29	-	HL	50043.660	9.99	10.53	9.50	−0.92	SP
49653.650	9.15	10.10	9.33	-	SP	50044.619	9.99	10.52	9.48	−0.94	SP
49658.50	9.21	10.19	9.76	-	HL	50049.680	10.09	10.60	9.57	−0.87	SP
49666.415	9.34	10.20	9.36	-	SP	50051.660	10.10	10.58	9.56	−0.86	SP
49688.30	9.59	10.50	9.45	-	HL	50052.625	10.08	10.57	9.53	−0.89	SP
49705.228	9.58	10.47	9.56	-	SL	50067.267	10.17	10.65	9.59	-	SL
49705.288	9.72	10.51	9.60	-	SL	50159.46	-	10.97	9.51	-	HL
49734.565	9.51	10.36	9.57	-	SP	50161.56	9.83	10.45	9.52	-	HL
49759.268	9.92	10.45	9.48	-	SL	50162.47	10.12	10.62	9.50	-	HL
49762.459	9.77	10.41	9.47	-	SP	50211.40	10.98	11.02	-	-	HL
49769.534	9.76	10.51	9.55	-	SP	50214.38	11.05	11.14	9.69	-	HL
49783.613	9.95	10.58	9.58	-	HL	50226.35	11.26	11.09	9.81	-	HL
49805.315	9.87	10.52	9.52	-	SL	50580.55	10.07	10.61	9.34	-	HL
49818.584	9.95	10.52	9.52	−0.79	SP	50583.51	10.53	11.13	9.87	-	HL
49854.366	9.56	10.47	9.54	−0.79	SP	50583.53	10.42	11.21	9.92	-	HL
49861.371	9.81	10.48	9.52	-	SP	50609.42	8.94	10.12	9.21	-	HL
49864.372	9.74	10.46	9.52	−0.85	SP	50610.42	8.65	10.01	9.12	-	HL
49889.511	9.50	10.34	9.46	−0.87	SP	50685.42	8.53	9.91	9.01	-	HL
49900.465	9.05	9.92	9.21	−1.07	SP	50688.37	9.33	10.06	9.04	-	HL
49905.419	8.89	9.81	9.15	−1.14	SP	50693.45	9.01	10.13	9.16	-	HL
49906.469	8.96	9.88	9.14	-	B	50697.44	9.66	9.90	9.17	-	HL
49907.439	9.00	9.90	9.15	-	B	50707.39	9.36	10.30	9.32	-	HL
49907.471	9.05	9.85	9.18	−1.10	SP	50708.39	9.55	10.35	9.32	-	HL
49921.393	8.70	9.68	9.02	-	SL	50712.39	9.51	10.41	9.37	-	HL
49924.544	8.78	9.70	9.03	−1.19	SP	50714.37	9.44	10.39	9.35	-	HL
49925.432	8.72	9.58	8.98	−1.23	SP	50721.37	9.94	10.65	9.56	-	HL
49926.448	8.79	9.62	9.02	−1.12	SP	50742.371	-	-	9.55	-	HL
49942.320	8.78	9.74	9.11	-	SL	50745.334	10.76	10.87	9.61	-	HL
49943.485	8.75	9.67	9.06	−1.22	SP	50749.345	10.59	10.92	9.64	-	HL
49952.378	8.46	9.43	9.08	-	HL	50751.299	10.75	10.87	9.67	-	HL
49967.331	-	10.00	9.14	-	HL	50753.356	10.93	10.92	9.64	-	HL
49968.329	9.18	10.03	9.25	−1.07	SP	50840.308	11.42	11.02	9.78	-	SL
49970.329	9.18	10.02	9.25	-	SP	50849.533	11.41	11.07	9.80	-	SL
49978.384	-	10.15	9.10	-	HL	50862.467	11.42	11.11	9.82	-	SL
49979.42	9.05	-	9.10	-	HL	50865.319	11.35	11.03	9.79	-	SL
49979.610	9.14	10.03	9.26	−1.07	SP	50866.308	11.35	11.05	9.81	-	SL
49986.35	9.26	10.15	9.32	-	HL	50870.329	11.31	11.04	9.80	-	SL

Obs = Observatory: SP - Skalnaté Pleso, SL - Stará Lesná, HL - Hlohovec, B - Brno

Table 2: Periodicities (in days) obtained for the different stages of AG Draconis in various bands

	P_U [d]	P_B [d]	P_V [d]
quiet stage	552.49	549.8	529.9
active stage	354.11	352.1	353.1

We can summarize, that there are two periods in general: i) one of 552.486 days which was determined as the orbital one by Meinunger (1979) and Kenyon and Garcia (1986) and ii) one of about 350 days. The latter reflects probably the pulsations and irradiation effect in the atmosphere/envelope of the cold component. We suppose that the source of the brightness increase during the outburst could be connected with the red giant (Friedjung et al. *in press*). This is in agreement with the fact that the pulsation period appeared during the active stages in all colours and during quiescence only in longer wavelengths.

Another problem of the interpretation is the duration of the 1994-1997 active stage. Our last points from Table 1 show probably the end of this recent outburst activity after 3.5 years. (Nevertheless we strongly encourage any interested observers to stay with this star as long as possible.)

We point out, that this was the most active stage of AG Dra, since four outbursts appeared during four years on the LC (Fig. 2).

It is of particular interest, whether these four outbursts belong to the same physical mechanism or not, despite the fact, that they appeared with the period of 350 d. As for the outbursts in 1980-1981 and 1985-1986, Mikolajewska et al. (1995) mentioned, that the UV behaviour of them was absolutely different, those in 1980-1981 became bluer while those of 1985-1986 became redder.

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TO OWNERS AND KEEPERS OF PLATE COLLECTIONS OBTAINED TO STUDY FLARE STARS IN STAR CLUSTERS

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About a dozen observatories have large plate collections that were obtained for studying flare stars in stellar clusters by the chain method. The collections were accumulated mainly in 60-80-es and permitted to detect several thousand red dwarf flare stars. However, the last 10-15 years these collections are practically not used. I should like to propose a second life for these plates: to use them to study the spottedness of flare stars.

As a rule, there are photometric standards on a plate with a stellar cluster. If not, they can be obtained additionally. The job that I propose is measurements of stellar brightness in that chains which are free from flare effects. If a collection covers 10-15 years or more, these measurements can provide the data necessary to study stellar spottedness of many dozens of the cluster members, the stars of the same age.

Since spottedness effects are from 0.4 down to several hundredths of stellar magnitude (Alekseev and Gershberg, 1996), the measurements should be rather accurate. In principle, the spottedness effect is a differential one, and for a large collection it would be enough to detect brightness differences only for different epochs. However, to unite data of various collections it is necessary to determine the stellar magnitudes, not their differences, accounting for systematic photometric errors over a field of telescopes used. In any case, it is necessary to publish lists of standard stars used.

Long-term variations of stellar spottedness give a direct information on stellar activity cycles (Phillips and Hartmann, 1978; Hartmann et al., 1981; Bondar, 1995). However, up to date the main source of these data was the long-term observations of stellar chromospheric activity (Baliunas et al., 1995). Unfortunately, among 111 stars, studied during 25 years of these observations, there is only one late dwarf Lalande 21185 (=Gliese 411) of dM2.1e spectral class, but no periodicity was found in its very variable chromospheric emission. The latest spectral class star, where Baliunas et al. (1995) have found some periodicity is K7 dwarf HD 201092. Recently the activity cycle of the flare star EV Lac was detected on the base of statistics of its flares (Alekseev and Gershberg, 1997). However, only a few stars have long enough photometric series for such studies.

According to a contemporary active discussion on stellar magnetism of low-mass stars (Drake et al., 1996), in completely convective stars of about 0.3 solar masses, the solar type dynamo mechanism should cease to operate and to generate large-scale solar type magnetic field. Instead, a turbulent dynamo mechanism comes into effect, that should have no cyclicity. Therefore a study of spottedness of late-type stars and search for the existence of activity cycles of late M stars is of high interest.

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PRECISE LIGHTCURVE ELEMENTS FOR HD 143213

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The variability of HD 143213 = SAO 121294 = GSC 353-301 was discovered by the TYCHO instrument of the HIPPARCOS satellite (Makarov et al., 1994). Among the 103 usable measurements in the B_T and V_T photometric channels there were a few discordant (fainter) ones which indicated a possible eclipsing binary. The small number and unsuitable temporal distribution of them made any more definite statement impossible. In IBVS No. 4536 we published a classification as Algol variable with a slightly offset secondary minimum and a preliminary period of 3.4500 days (±0.0003 days). These results, derived from visual magnitude estimates by E. Born, were fully confirmed by the TYCHO data. However, there was a strong discrepancy in the phase of the lightcurve between the visual and the TYCHO data. No reason for the discrepancy could be found in checks of the original observations, and it was too large to be plausibly explained by a period change of the variable during the six years between the TYCHO and the visual observations.

Further observations by E. Born showed the period to be correct as well as constant, thus making a period change ever more implausible. More checks finally revealed an error in the epochs of the TYCHO data that we had used. The data had been extracted from the TYCHO-internal data base, and an obsolete routine for the computation of Julian dates had inadvertently been used in the process. All JDs given for the TYCHO observations in Table 1 of IBVS No. 4536 have to be increased by exactly 1.5 days. This correction gave a perfect agreement between the TYCHO and the visual data. A least-squares fit through all available timings of primary minima yielded

$$\mathrm{JD(min)} = 2450304.357\ (\pm 0.011) + 3.449896\ (\pm 0.000062) \times \mathrm{E}$$

For this computation, mean errors as given in Table 1 of IBVS No. 4536 were used for the visual timings, while 0.04 days were conservatively adopted for the isolated TYCHO observations at primary minima (corresponding to 1/4 of the total width of the primary minimum). An analogous, independent fit through the available timings of secondary minima yielded a fully consistent period of 3.449820 (±0.000048) days and a mean phase of 0.541 ±0.006, i.e. a slight but highly significant offset from phase 0.5.

It should be pointed out that the epoch error reported here is only in the internal TYCHO data used for our preliminary analysis of HD 143213 in IBVS No. 4536. It is neither present in the already published Tycho Epoch Photometry Annex A of 34 000 stars, nor in the forthcoming Tycho Epoch Photometry Annex B of 480 000 stars.

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ON THE VARIABILITY OF S STARS AS OBSERVED BY THE HIPPARCOS SATELLITE

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The local part of our Galaxy contains two kinds of cool peculiar red giants of spectral type S: the intrinsic S stars with high luminosity, Tc lines in the spectra, and chemical peculiarities which were produced by intrinsic nucleosynthetic processes and the extrinsic non-Tc binary S stars which have evolved from the barium stars (Iben & Renzini 1983, McClure & Woodsworth 1990). Groenewegen (1993) examined Stephenson's (1984) catalog of S stars, Little et al. (1987), and Smith & Lambert (1988, 1990) and found 27 stars without Tc and 36 stars with Tc. Further he photometrically separated many of these stars into two groups. Simultaneously Jorissen et al. (1993) performed a similar study on the correlation between Tc lines, binary, and infrared excesses.

Recently by use of Hipparcos parallaxes Van Eck et al. (1998) found the intrinsic Tc-rich S stars are thermally pulsating AGB stars of low and intermediate masses while the extrinsic Tc-poor stars comprise mostly low-mass stars on either the red giant branch or the early AGB. The later are binaries with an average mass of 1.6 ± 0.2 $M_{\odot}$. Unfortunately Hipparcos parallaxes were not obtained for most of the large amplitude variables. Their division of S-stars is similar to that of Groenewegen (1993) and Jorissen et al. (1993). When a variability type is given for any large amplitude variable it is listed as a Mira.

The Hipparcos photometry (ESA 1997) provides data on many S stars with and without Tc lines in their spectra. Table 1 shows for each observed star the average magnitude, the standard error, and the amplitude (95th - 5th percentile magnitudes), any known periods from the GCVS (Kholopov et al. 1988), and the variability type (Stephenson 1984). The periods from Hipparcos when given are very similar to these. We also included Hipparcos periods for o^1 Ori, χ Cyg, and HR 363. Especially striking is that almost all large amplitude variables (those with amplitudes greater than 1 magnitude) are intrinsic S stars. Those stars with amplitudes of 2.24 mag or greater have periods longer than 220 days. This is in accord with Little et al. (1987) who found that M star Mira variables tend to show Tc for periods greater than 300 days.

V Cnc is the only possible extrinsic S star with a large amplitude. But it is uncertain whether it has Tc lines in its spectrum. If it is an intrinsic S star, then the extrinsic binary S stars would be more unified in their class properties. Their amplitudes would represent the typical pulsations from similar single stars with a mean amplitude of 0.11 $\pm$ 0.07 mag (19 stars). Of the intrinsic S stars, 8 have similar amplitudes while 10 have intermediate amplitudes. Smith & Lambert (1988) found four of these stars NO Aur,

Table 1: Hipparcos Photometry of Various S Stars

Name	HD	HIP	Average mag.	Standard error	Ampl. (mag.)	Period (days)	Sp. Type
			Stars with Tc lines				
T Cet	1760	1728	5.4391	0.0334	0.66	158.9	M5S
R And	1967	1901	10.7054	0.0114	2.97	409.3	S6,6e
W And	14028	10687	8.0759	0.2264	2.24	395.9	S7/1e
o^1 Ori	30959	22667	4.7029	0.0052	0.09	30.29	S3/1
NO Aur	37536	26718	6.2431	0.0111	0.17		M2S
R Gem	53791	34356	7.5292	0.4569	3.78	369.9	S5/5
AA Cam	54587	35045	7.5787	0.0079	0.48		M5S
Y Lyn	58521	36288	6.8979	0.0051	0.75		M6S
	63733	38217	7.9816	0.0021	0.08		S4/3
NQ Pup	64332	38502	7.5320	0.0155	0.22	120.	S5/2
RS Cnc	78712	45058	5.4500	0.0267	0.93		M6S
HR 4647	106198	59588	6.1429	0.0101	0.51		M4S
S UMa	110813	62126	8.9095	0.1489	3.01	225.9	S3/6e
ST Her	142143	77619	6.9206	0.0262	0.71	148	M6.5S
S Her	152276	82516	8.2809	0.2368	4.10	307.3	M4Se
OP Her	163990	87850	6.1059	0.0102	0.35	120.5	M5S
	170970	90723	7.4571	0.0027	0.11		S3/1
T Sgr	180196	94706	10.8263	0.2237	3.97	394.7	S5/6e
χ Cyg	187796	97629	6.1696	0.1686	5.19	402.3	S7/1.5e
AA Cyg	190629	98856	8.1592	0.0376	1.01	212.7	S6/3
	191630	99758	6.7577	0.0046	0.15		S4,4
	199799	103476	7.2485	0.0168	0.27		MS
HR 8062	200527	103828	6.1764	0.0046	0.18		S4/1
X Aqr	211610	110146	10.1887	0.1796	3.66	311.6	S6,3
π^1 Gru	212087	110478	5.4957	0.0119	0.80		S5,7:
HR Peg	216672	113131	6.3460	0.0164	0.23	50	S4/1
			Stars without Tc lines				
	310	621	7.5704	0.0038	0.09		S3.1
	6409	5091	7.4622	0.0043	0.10		M2wkS
HR 363	7351	5772	6.3950	0.0045	0.09	7.494	S3/2
BD Cam	22649	17296	5.0956	0.0035	0.10		S4/2
	29704	21688	8.2551	0.0098	0.24		S:
	35155	25092	6.8824	0.0115	0.21		S3/2
V613 Mon	49368	32627	7.7492	0.0041	0.16		S3/2
NZ Gem	61913	37521	5.5874	0.0033	0.08		M3S
V Cnc	70276	40977	9.2621	0.1521	2.59	272.1	S3/6e
DE Leo	90254	51008	5.6925	0.0055	0.06		M3S
	96360	54396	8.0759	0.0060	0.19		M3Swk
	119667	67070	8.5417	0.0024	0.05		M1Swk
	150922	81970	7.8030	0.0049	0.08		M2S
	151011	82038	6.6890	0.0029	0.05		Swk
	165774	88940	8.2111	0.0032	0.07		S4,6
V1743 Cyg	184786	96198	6.0075	0.0092	0.18		M5S
	191226	99124	7.3741	0.0020	0.07		M3S
	191589	99312	7.3682	0.0017	0.06		S
	215336	112227	7.9295	0.0019	0.06		Swk
GZ Peg	218634	114347	5.0336	0.0117	0.24	92.7	M4S

HD 63733, ST Her, and HD 170970 to have wavelengths of the λ 4262 line just at the boundary between Tc-rich and Tc-poor stars. Three have amplitudes in the extrinsic S star range. However a resolution of 0.18 Å is insufficient to cleanly separate the two types of S stars. According to Jorissen et al. (1993) HD 63733 and HD 170970 are really extrinsic S stars being binary and lacking infrared excesses. Ake & Johnson (1988) discuss o^1 Ori which is another outlyer in the Tc-rich stars. It has a white dwarf companion and intrinsic S star features. Hence the other S stars in the intrinsic list with amplitudes like those of the binary stars should be studied carefully to make sure they are in the correct category.

Adelman (1998) found that BD Cam was pulsating with a period of 24.76 days with an amplitude of almost 0.20 magnitudes. This was superimposed on the binary period of 596.21 $\pm$ 0.19 days found by Griffin (1984). HD 35155 acts in a somewhat similar manner with the intrinsic variations superimposed on an eclipsing behavior which is related to the orbital motion (Jorissen et al. 1992, 1996). As both are extrinsic binary S stars, we might expect that the other extrinsic S stars exhibit somewhat similar behavior. In making comparisons between Hipparcos light curves, a difficulty is that the sampling depends on where the star is in the sky. Many observations are closely bunched rather than sampled in a more random manner. The Hipparcos light curves of these stars (except for V Cnc) look like random samples of pulsating stars with periods of order a month. A complete demonstration requires photometry which samples the light of these stars every few days.

Of the intrinsic S stars, T Cet shows a systemic decline of about 0.8 mag. with pulsations superimposed. The large amplitude intrinsic S stars tend to have fragmentary light curves for the most part with suggestions of pulsation. The smaller amplitude stars have light curves often resembling those of the extrinsic S stars. But AA Cam shows a definite minimum as does HD 63733.

The intrinsic S stars show a range in amplitude variability with periods between 30 and 419 days. But many such stars still have periods to be determined. It is possible that all the large and medium (0.3 - 1.0 mag.) amplitude variables are intrinsic S stars and the small amplitude variables are extrinsic S stars. Thus the conclusion of Little et al. (1987) that Miras with periods greater than 300 days tend to be what are known as intrinsic S stars is confirmed and extended.

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A NEW δ SCUTI VARIABLE STAR – SAO 16394†

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In order to monitor δ Scuti variable star HR5437 the 4-channel photometer (Michel and Chevreton 1991) with Strömgren b filter was used. SAO 16408 was used as comparison, and SAO 16394 (HD 127411, A2, V=7.2) was used as check star. The three stars and sky background were observed simultaneously. All data were collected from 8 to 17 April 1997 using the 85 cm telescope at the Xinglong Station of Beijing Astronomical Observatory. The integration time was one minute. The time series of data covered about 42 hours. No evidence for any variability of SAO 16408 was found. However, we found variations in the brightness of SAO 16394. The light curves are shown in Fig. 1, where the ordinate is the b magnitude difference normalized to zero. We used Hao Jin-xin's program (1991) and the program PERIOD96 (Breger 1990, Sperl 1996) to complete the period analysis. Two frequencies were obtained. They are 23.06 cd^{-1} with an amplitude of 0.0044 mag, and 16.84 cd^{-1} with an amplitude of 0.0039 mag. The two-frequency solution can fit the light curves quite well (see Fig. 1). The fit curve of two frequencies is shown as a solid curve. Because the amplitudes of two frequencies are very small, the star SAO 16394 may be a nonradial δ Scuti star.

The interval covered by our data is short, therefore the precision of frequencies and amplitudes obtained might be low. In order to obtain more accurate results further observations are required.

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†Based on observations collected at the Beijing Astronomical Observatory (China)

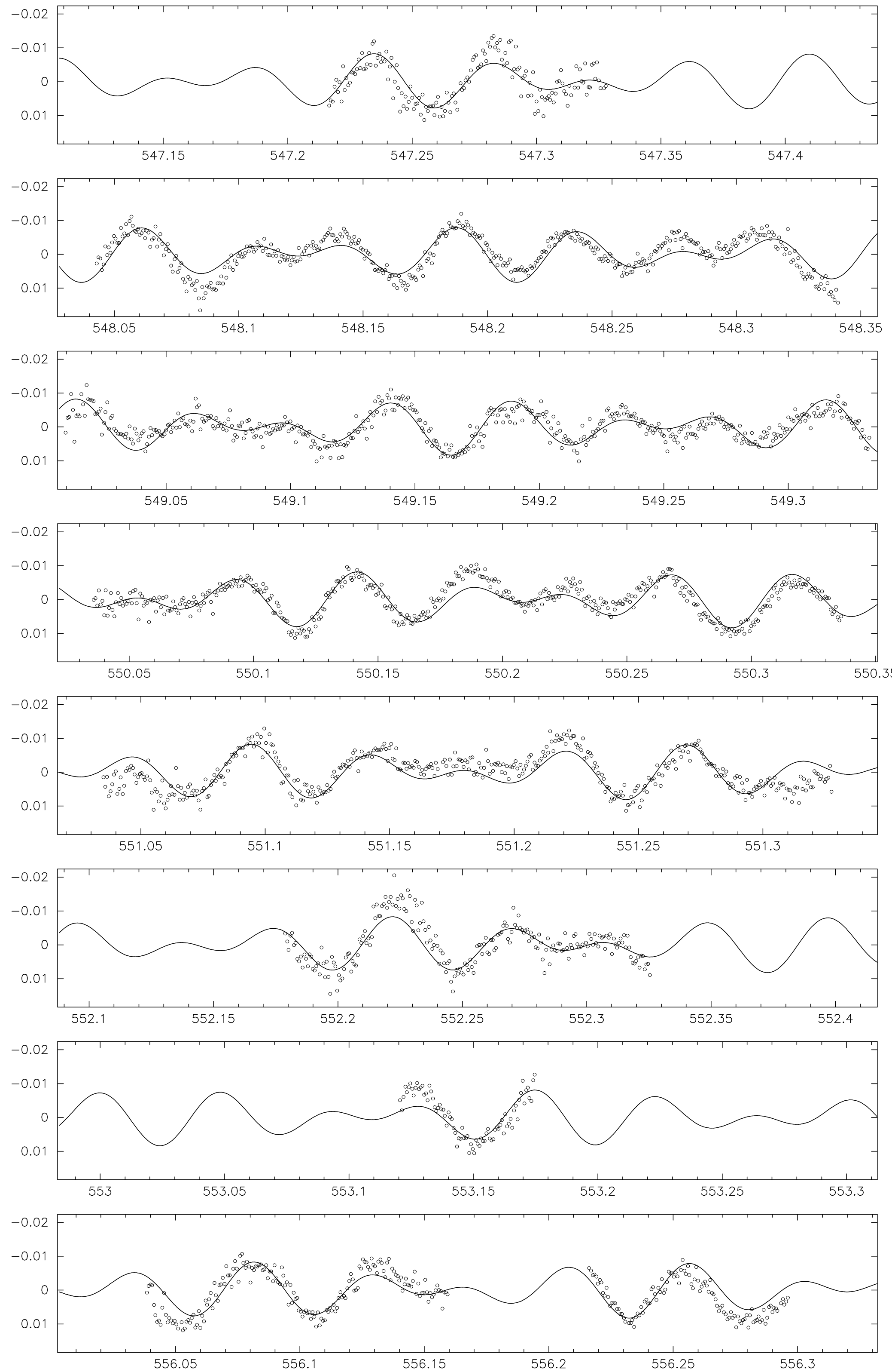

Figure 1. Light curve of SAO 16394 obtained in April 1997. The ordinate is the b magnitude difference (SAO 16394−SAO 16408) normalized to zero. The fit of the two-frequency solution is shown as a solid curve. The abscissa is the time (+HJD 2450000)

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DISCOVERY OF PULSATIONS IN THE DOUBLE STAR HD 13079

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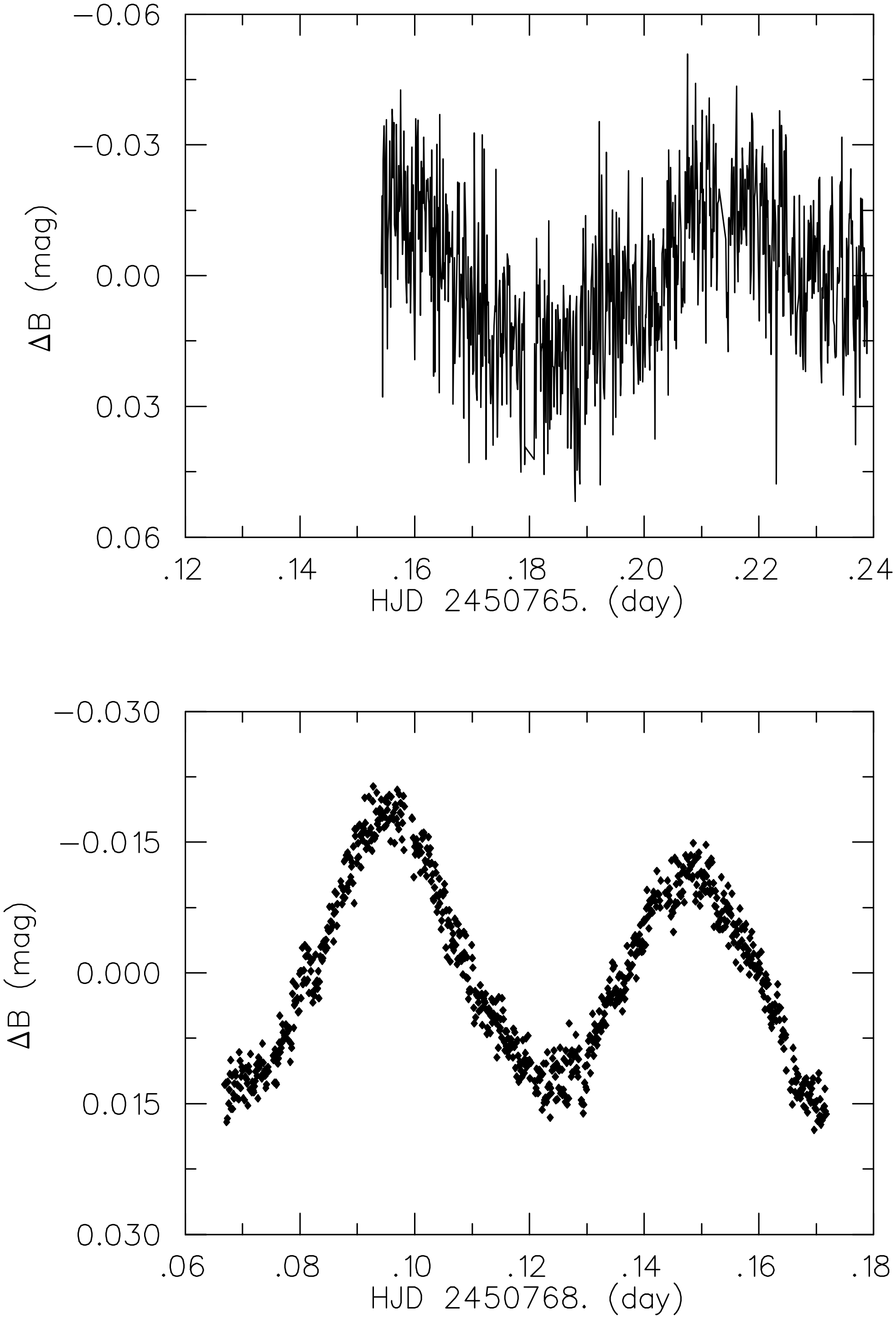
Single-channel, time-series photometric observations of HD 13079 (BD+38°418 = HIC 10023 = CCDM 02090+3936) were acquired on nights 12/13 and 15/16 November 1997 using the 1-m telescope of the Uttar Pradesh State Observatory at Naini Tal. The measurements included the light of both components, which are separated by only 6.17 arcsec. The data were acquired as continuous 10-s integrations through a Johnson B filter. Since we were searching for oscillations in the range 5–16 min we did not observe HD 13079 differentially with respect to comparison stars. The data were corrected for coincidence counting losses, sky background and atmospheric extinction.

The light curves obtained on these two nights are shown in Fig. 1. The scale of the ordinates in the two panels is different and individual observations are not plotted in the top panel as the scatter makes the trend hard to follow. The the first light curve had significantly higher noise than the second owing to misbehaviour of the photomultiplier tube. The second light curve was acquired with a new photomultiplier tube and it shows a convincing 72-minute variation. The slight difference in the amplitude of the two cycles suggests the possible presence of another frequency.



−0.06
−0.03
0.00
0.03
0.06
ΔB (mag)
.12
.14
.16
.18
.20
.22
.24
HJD 2450765. (day)
−0.030
−0.015
0.000
0.015
0.030
ΔB (mag)
.06
.08
.10
.12
.14
.16
.18
HJD 2450768. (day)

Figure 1.

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OBSERVATION OF THE OPTICAL COUNTERPART OF GRB 970508

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Name of the object:
GRB 970508

Equatorial coordinates:	**Equinox:**
R.A.= $6^{h}53^{m}49\overset{s}{.}2$ **DEC.=** $+79°16'19''$	2000.0

Observatory and telescope:
Ostrowik Observatory, 0.6 m Cassegrain

Detector:	Tektronix TK512CB backside illuminated, 512x512 pixels; pixel size is 27 μm, which corresponds to the scale 0.74 arcsec/pixel (Udalski & Pych 1992)

Filter(s):	R (Cousins) and white light

Transformed to a standard system:	UBVRI
Standard stars (field) used:	star at R.A. = $6^{h}53^{m}48\overset{s}{.}5$, Decl. = $+79°16'32\overset{''}{.}7$ (2000.0), about $3''$ west and $13''$ north of the GRB 970508, R = 19.70 mag (Schaefer et al. IAU Circ. No. 6658)

Availability of the data:
upon request

Remarks:
The observations were made on five consecutive nights from May 9 to May 13, 1997. The exposure times varied between 420 and 720 seconds, depending on atmospheric conditions and sky transparency. Data reduction have been performed with IRAF, profile photometry has been done using the DAOPhot/Allstar programs (Stetson 1987). Based on observational data from Bond (1997) we identified the optical counterpart of GRB970508 in one of the averaged frames in spite of poor weather conditions. We measured its brightness: R = 19.71 $\pm$ 0.26 mag. This example shows that even small telescopes are suitable for finding such faint objects as optical counterparts of gamma-ray bursts.

Acknowledgements: We wish to thank to Prof. J. Madej for many helpful discussions and comments on this manuscript. Thanks are also due to Mr. P. Powalko and to Mr. J. Drelowiec for assistance in observations. This research has been supported by grant No. 2 P03D 002 12 from the Polish Committee for Scientific Research.

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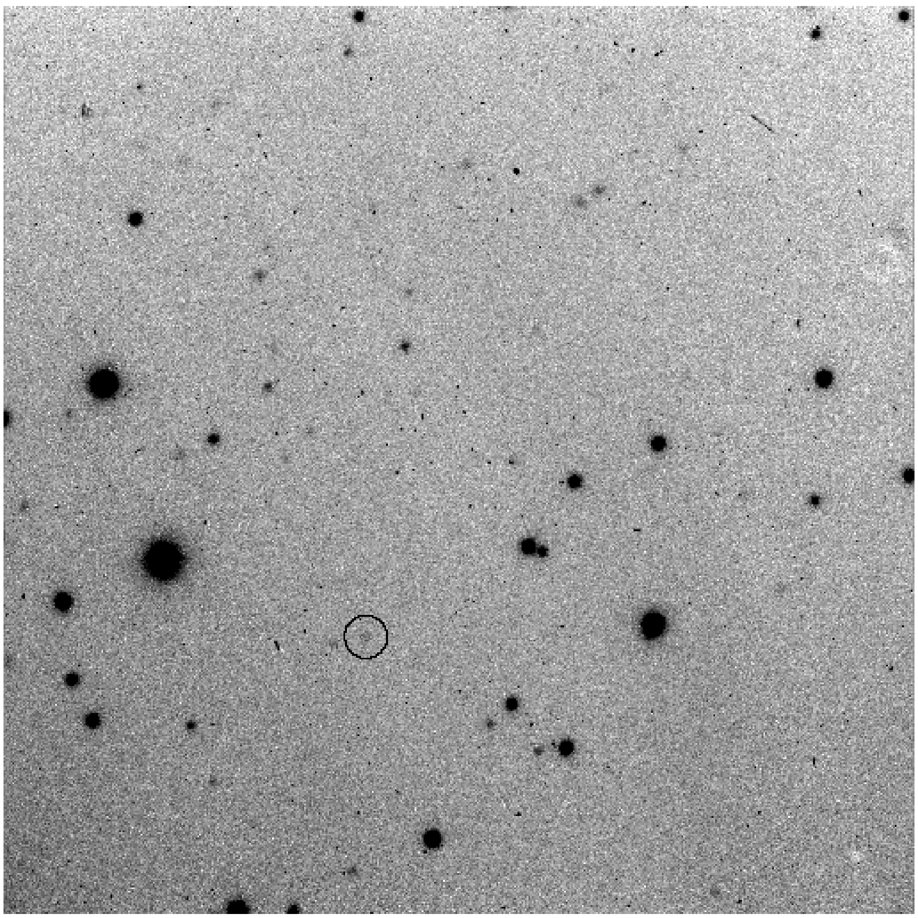

Figure 1.

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PERIODIC LIGHT VARIATION IN B416 A LUMINOUS BLUE STAR IN M33

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In a search program for potential SS433-like candidates in M33, carried out at the Wise Observatory in 1986 and 1987, we discovered periodic light variations in one of our program stars. It is a blue star designated B416 in the M33 bright blue and red stars catalogue of Humphreys & Sandage (1980). The star is an Hα emitter, and it is No. 24 130e in field 1 of the Hα survey of Calzetti et al. (1995), who give its 1950 coordinates as:

$$\mathrm{RA}=01^{\mathrm{h}}31^{\mathrm{m}}17\overset{\mathrm{s}}{.}370;\ \mathrm{DEC}=+30^{\circ}26'26\overset{\prime\prime}{.}26$$

According to Calzetti et al., the magnitude of the star is m_V=16.76 and the EW of its Hα emission is 109.1Å. With the distance modulus of μ=24.5 for M33, and taking into account a foreground extinction towards this galaxy of A_V=0.22 (Van Den Bergh 1991), we obtain an estimated absolute magnitude of $M_V=-7.96$, making this star a highly luminous object.

The measurements in 1987 were performed with the Wise Observatory 320×520 pixel, thinned RCA CCD camera, with no filter (Clear), in 23 nights spread over an interval of 60 days. The power spectrum of the light curve shows a clear dominant peak at the frequency corresponding to the period P=8.55 days. The amplitude of the variation is 0.026 mag.

The star was monitored again in the 1997-98 season using the Wise Observatory 1024×1024 pixel, back-illuminated Tektronics CCD camera in Clear, V and B filters. The power spectrum of 51 Clear measurements, taken in 51 nights spread over an interval of 180 days is shown in Figure 1. It has a clear peak at P=8.13 days, which is statistically significant at a 99% confidence level. Figure 2 shows the light curve, folded on this period. It is rather sinusoidal with an amplitude of 0.026 mag. The power spectrum of a combined light curve, consisting of 74 Clear nightly measurements in 1987 and 1997/98 has a prominent peak at P=8.13 days. The same periodicity is also apparent in the light curves in the V and B filters.

We suspect that the coherent photometric variations indicate binarity, and that the 8.13 day periodicity, or possibly twice this value, is the binary period of the system.

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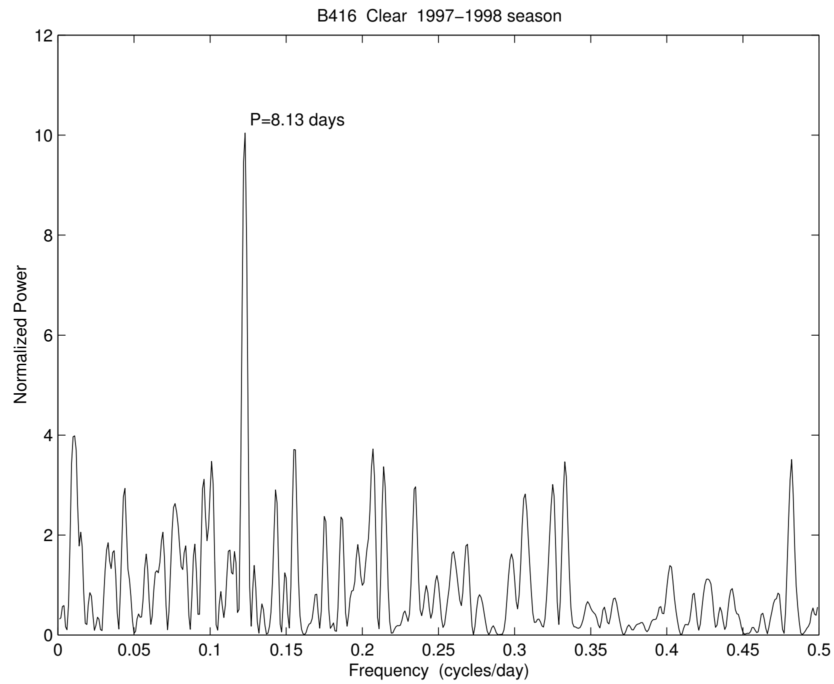

Figure 1. Power spectrum of the 1997/98 light curve of B416, consisting of 51 Clear data points. The high peak indicates a period of 8.13 days

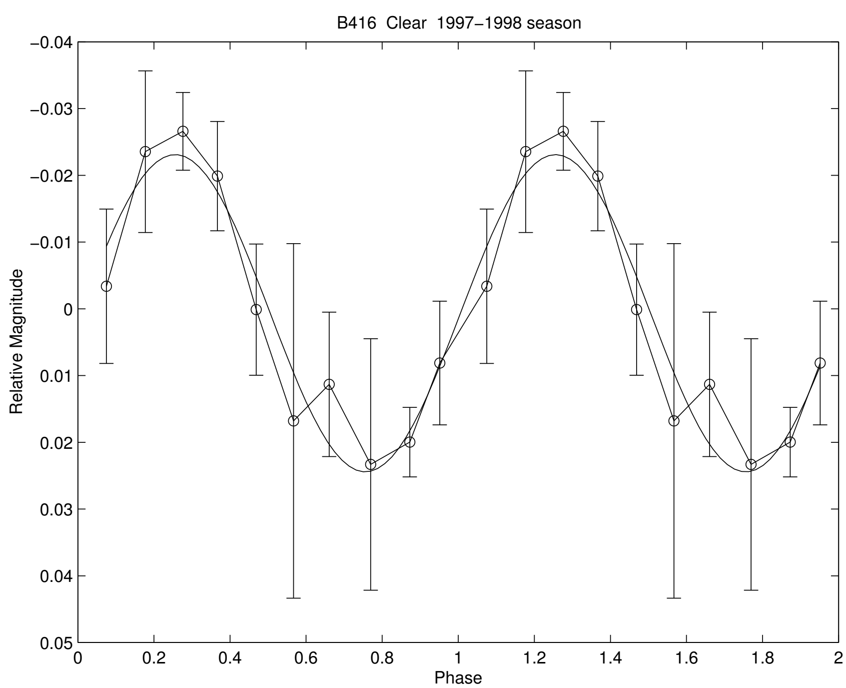

Figure 2. Phase diagram of the 51 Clear data points of 1997/98, folded on the period of 8.13 days and divided into 10 bins per cycle (open circles). A sine wave with this period is fitted by least squares to the folded data (solid line). The vertical bars represent the error bars of the binned light curve

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HD 62454 – A NEW SPECTROSCOPIC BINARY

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HD 62454 is a new addition to the "Master List" of γ Doradus–type Variables (Handler & Krisciunas 1997). This star was first recognized by Henry (1996) as a low–amplitude variable after it was chosen as a comparison star for high–precision photometry of solar–type stars with the SAO / TSU 0.75 m automatic photoelectric telescope (Henry 1995) and preliminary data were presented by Kaye et al. (1998).

Thirty-three high signal-to-noise ratio spectra were obtained over eleven nights at the Kitt Peak National Observatory during late November and early December of 1997. These spectra were taken simultaneously with photometry obtained at both Washington Camp, Arizona and Sierra Nevada, Spain (Kaye 1998). The signal-to-noise ratio (SNR) is estimated to be approximately 275. Each spectrum covers the wavelength region 4403 to 4617 Ångströms and were obtained using grating A, camera 5, and the long collimator. Filter 4-96 was used to block both higher and lower orders. Data were recorded on the F3KB CCD (3000×1000 pixels, 15×15 μm pixel size, 75% detector quantum efficiency (DQE) at 4210 Ångströms); these spectra have a reciprocal dispersion of 0.070 Ångströms per pixel (4.643 Ångströms per millimeter), resulting in a resolving power of approximately 34,400. The slit width was fixed at 250 μm, which corresponds to 1.81 seconds of arc. The projected slit image was 0.027 mm and covered 1.77 pixels.

Subsequent analysis based on the the time series of first moments of the Fe II λ 4508.289 photospheric line indicates that HD 62454 is a spectroscopic binary. Table 1 lists the measured radial velocities (plotted in Figure 1), and Table 2 presents the preliminary orbital elements of the system. The standard deviation of the orbital fit (noted as σ in Table 2) is higher than expected due to the ongoing pulsations present in HD 62454a.

A complete photometric analysis and a preliminary spectroscopic analysis (using the method of moments as related to the "γ Doradus phenomenon") are presented in Kaye (1998).

Table 1. Radial Velocities of HD 62454a

HJD−2450700	V_r
77.9570	54.4103
77.9784	54.8054
78.8511	52.0470
78.8726	51.1388
78.9613	49.9706
78.9827	49.7631
80.7640	29.3740
80.7852	28.9516
80.8063	29.0373
80.8790	27.6276
80.9002	27.2981
80.9214	26.9832
81.7426	11.2322
81.7903	10.0462
81.8850	8.6168
81.9515	7.6767
81.9982	6.6965
82.7728	−6.4372
82.9963	−9.5304
85.8779	−42.5398
85.8990	−42.0260
85.9202	−41.9840
86.0076	−41.8618
86.0287	−42.1527
86.8909	−23.2998
86.9121	−22.8126
86.9783	−22.4151
87.0341	−20.0233
87.7519	9.1827
87.8523	15.0026
87.8734	16.0439
87.9550	20.2169
87.9762	20.6628

Table 2. Preliminary Orbital Elements of HD 62454a

Orbital Element	Value
γ	10.87 ± 0.10 km s^{-1}
K_1	50.79 ± 0.17 km s^{-1}
e	0.166 ± 0.002
Ω	$179\overset{\circ}{.}45 \pm 0\overset{\circ}{.}011$
$T_0 - 2450700$	70.87 ± 0.04
P	14.02 ± 0.02 days
mass function	0.183 ± 0.002
σ	5.62 km s^{-1}

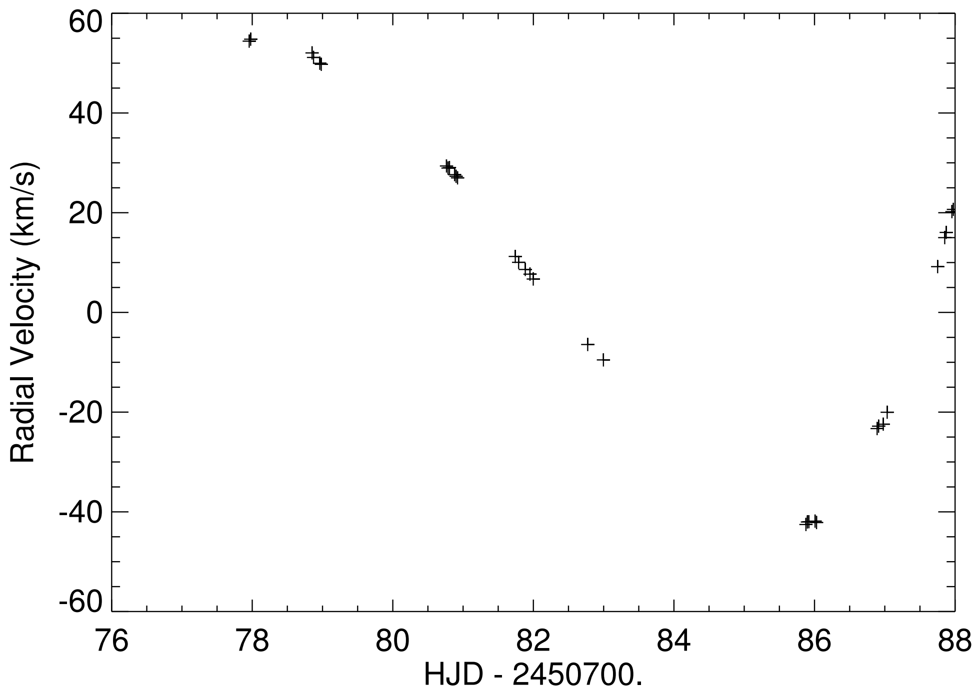

Figure 1. A radial velocity curve of the primary star (HD 62454a) based on the first moments of the Fe II λ 4508.289 line

I thank Dr. W.G. Bagnuolo and Dr. D.R. Gies for useful conversations. In addition, thanks are due to the administration and the staff of KPNO for the telescope time and for assistance during the observations and the data reduction process.

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ERRATUM

When checking the data published in the IBVS No. 4543 issue for updating and supplementing the variable star catalogs, several incorrect and confusing statements have been found.

The last sentence of the first paragraph should read as follows:

Object 4 is NGC 13386 (Wisniewski and Coyne, 1976, hereafter WC) and object 13 is NSV 13792 (Geyer and Gieseking, 1975, hereafter GG).

In Table 1, Note 2 should be in the SAME line with Note 1 (both belong to NSV 13792).

On page 2, the contents of Note 5 and Note 2 are interchanged.

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TIMES OF MINIMA OF ECLIPSING BINARIES

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We report times of minima of eclipsing binaries derived from photometric observations made at the High Altitude Maidanak Observatory in Uzbekistan in Johnson B,V filters, and at the University of Arkansas (unfiltered CCD observations; all but one of the Arkansas minima were observed by JLC). Heliocentric times of minima were estimated for each filter by using the method of Kwee and Van Woerden (1956) as adapted to a Macintosh computer. The adopted time of minimum was then the average over both filters for Maidanak data. In all cases the times of minima in different filters were concordant. Uncertainties in the times of minima were estimated from the values of standard error computed by the method and from the differences in times derived from the various filters used. In Table 1, primary eclipses are designated as type 1 eclipses, and secondary eclipses as type 2.

Table 1

Star	JD of Min −2400000	Type	Observatory
KP Aql	50670.6586 ± 0.0008	1	Arkansas
WW Cam	50319.3520 ± 0.0005	2	Maidanak
	50667.3343 ± 0.0004	2	Maidanak
	50675.3063 ± 0.0005	1	Maidanak
	50843.6054 ± 0.0002	1	Arkansas
	50852.7028 ± 0.0003	1	Arkansas
	50868.6209 ± 0.0004	1	Arkansas
AY Cam	50847.7598 ± 0.0004	1	Arkansas
IT Cas	50848.6032 ± 0.0009	1	Arkansas
PV Cas	50321.4771 ± 0.0006	2	Maidanak
V459 Cas	50307.3162 ± 0.0005	1	Maidanak
EK Cep	50311.3135 ± 0.0004	1	Maidanak

Table 1 (cont.)

Star	JD of Min −2400000	Type	Observatory
RT CrB	50640.3389 ± 0.0010	1	Maidanak
V442 Cyg	50725.7468 ± 0.0003	2	Arkansas
V541 Cyg	49935.3911 ± 0.0006	2	Maidanak
V909 Cyg	50284.3338 ± 0.0004	2	Maidanak
	50305.3752 ± 0.0003	1	Maidanak
	50312.3868 ± 0.0010	2	Maidanak
	50319.3520 ± 0.0005	2	Maidanak
	50622.3782 ± 0.0030	1	Maidanak
	50629.3962 ± 0.0020	2	Maidanak
	50653.2405 ± 0.0010	1	Maidanak
	50660.2535 ± 0.0010	2	Maidanak
	50689.7076 ± 0.0004	1	Arkansas
	50682.6993 ± 0.0007	2	Arkansas
V364 Lac	49947.4106 ± 0.0010	1	Maidanak
	50686.3545 ± 0.0009	2	Maidanak
RU Mon	50837.6714 ± 0.0004	1	Arkansas

For some of the binaries, JLC has collected from the literature all published dates of minima in order to improve the eclipse ephemerides. Based on a preliminary analysis of all data, visual dates of minima were assigned a standard error of 0.014 days, photographic dates were assigned a standard error of 0.018 days, relatively old photoelectric minima were assigned a standard error of 0.0037 days, and recent photoelectric minima were assigned a standard error of 0.0020 days unless the standard error was explicitly stated in the publication. A weighted least squares fit to the dates of minima resulted in the improved ephemerides listed in Table 2.

Table 2

Star		Period (days)	Zero Epoch (HJD)− 2400000
KP Aql	Min I	3.3674753 ± 0.0000005	50670.6586 ± 0.0003
	Min II	3.3674748 ± 0.0000008	49931.4981 ± 0.0017
WW Cam	Min I	2.2743614 ± 0.0000006	50843.6050 ± 0.0002
	Min II	2.2743634 ± 0.0000023	41781.3914 ± 0.0056
AY Cam	Min I	2.7349681 ± 0.0000004	50847.7597 ± 0.0003
	Min II	2.7349627 ± 0.0000014	49555.4675 ± 0.0042
IT Cas	Min I	3.8966431 ± 0.0000008	50848.6186 ± 0.0006
	Min II	3.8966489 ± 0.0000009	49962.3378 ± 0.0008
V442 Cyg	Min I	2.3859454 ± 0.0000011	44919.5609 ± 0.0037
	Min II	2.3859378 ± 0.0000009	50725.7472 ± 0.0003
V909 Cyg	Min I	2.8053850 ± 0.0000009	50689.7076 ± 0.0004
	Min II	2.8053881 ± 0.0000011	50682.6994 ± 0.0007

Differences between the periods for Min I and Min II are expected for the eccentric eclipsing binary IT Cas due to apsidal motion (Lacy et al. 1997). The period of RU Mon, however, is found to be quite variable, suddenly increasing or decreasing in value (the average period is 3.5846 days, with sudden variations at the level of 0.0001 days), and cannot be well represented by a single linear ephemeris. RU Mon is discussed by Martynov & Khaliullin (1986). This erratic behavior cannot be due to simple apsidal motion mechanisms, and is likely due to some kind of mass loss or transfer, or some unknown mechanism. We would like to acknowledge financial support of our work by the American Astronomical Society through the Edith J. Woodward Award and from the Margaret Cullinan Wray Charitable Lead Annuity Trust.

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DOES V694 Mon ENTER AN INACTIVE PHASE?

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MWC 560 ≡V694 Mon is a very peculiar member of the symbiotic variables. The system consists of an M4.5 red giant and probably a magnetic white dwarf. The lack of evidence of orbital motion suggests a very low orbital inclination: the *face-on* orientation is quite probable. The same is suggested by the most intriguing feature of MWC 560 fast (1000–6000 km s^{-1}) and collimated jet along the line of sight, seen in the spectrum as a very broad and variable blue-shifted absorption of Balmer and singly ionized metal lines (Tomov et al. 1990, Shore et al. 1994). The star is supposed to be one of the prototypes of a possible new subclass of the symbiotic binaries, *propellers* (Mikołajewski et al. 1996). The luminosity of the hot component in these systems is partially derived from the stellar wind accretion and partially from the rotation of a white dwarf transferred into the accreted matter *via* the magnetic field (oblique rotator).

In this paper we present spectroscopic and photometric results for the last year. The spectra were obtained with the echelle spectrograph mounted on the 1.82m telescope of the Asiago Observatory. Photometric data were collected with the single channel UBVRI photometer mounted on 60 cm telescope at Toruń Centre for Astronomy (Poland) and UBV photometers at Belogradchik Observatory and Rozhen National Astronomical Observatory (Bulgaria), also attached to 60 cm reflectors.

In an earlier paper about MWC 560 (Mikołajewski et al. 1997) we presented the photometric behaviour of the star after its highest maximum in 1990, when it reached $B \approx 9\overset{m}{.}4$. Since then we have observed a systematic decrease until April 1997 when B dropped to about 12^{m}. During this period, brightness in UBVR bands varied in a very similar way. The changes of the I magnitudes were different and probably reflected variations of the red giant. In 1995 the system had a weak maximum that is consistent with 1930^{d} orbital period (Doroshenko et al. 1993) and may correspond to the periastron passage. The spectra showed wide, variable rectangular-shaped, jet-origin blue-shifted absorption components during the whole 1990–97 period (see also Tomov & Kolev 1997).

The significant drop in brightness in April 1997 (Mikołajewski et al. 1997) appeared to be only a temporary change because at the beginning of 1997/98 observational season (from October 1997 to April 1998) MWC 560 was slightly brighter again. However, there is a substantial difference in the character of the light curve. The scatter of colours has

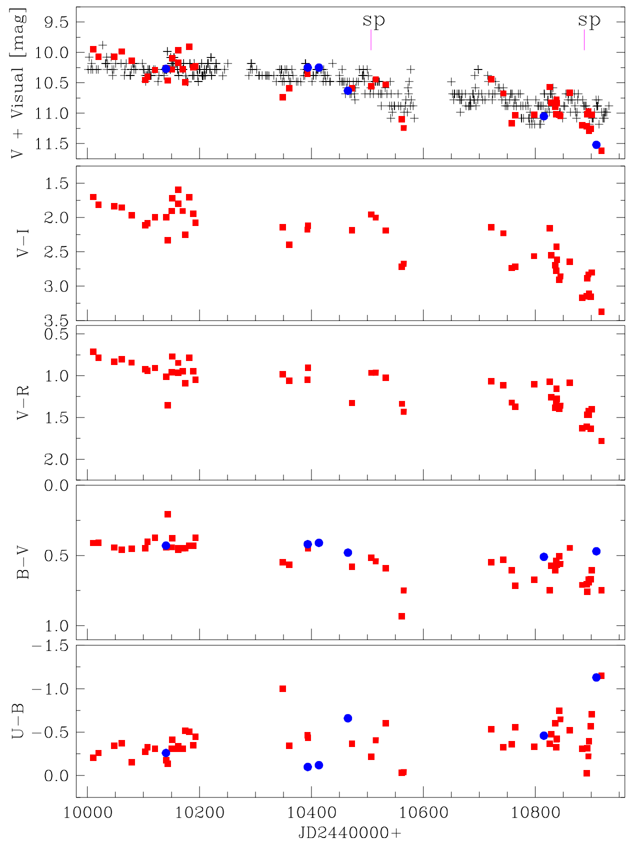

Figure 1. The colour light curves of MWC 560 during last three seasons (Oct 1995 – Apr 1998): Toruń UBVRI data (*filled squares*), Rozhen and Belogradchik UBV data (*filled circles*) and visual estimates by A.J. (*crosses*). The visual magnitudes are corrected by $-0\overset{m}{.}22$ as in Mikołajewski et al. (1997) and vertical lines mark the dates of spectroscopic observations shown in Fig. 3

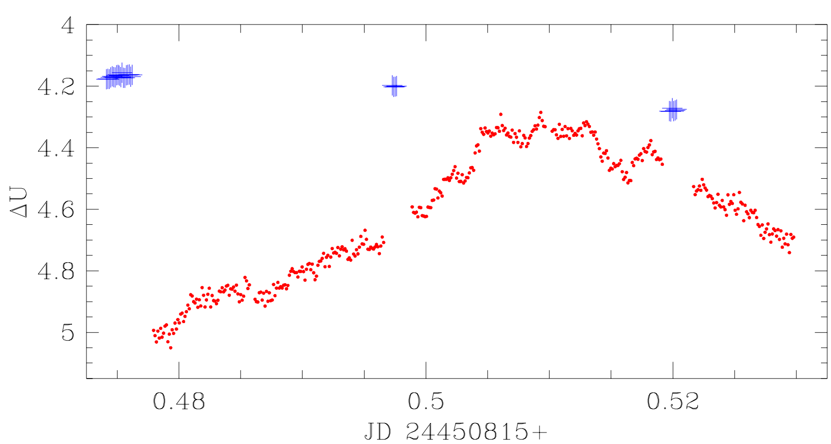

Figure 2. Flickering in U band on 1st January 1998. Crosses show the U magnitude of the comparison star (HD 59380) during the observation run shifted by a constant

significantly increased on a time scale of days to weeks (Fig. 1.) and more rapid decrease of the hot continuum, especially since January 1998, has been observed in BV bands. In April 1998 the V–R and V–I indices reached values typical for an M–type giant.

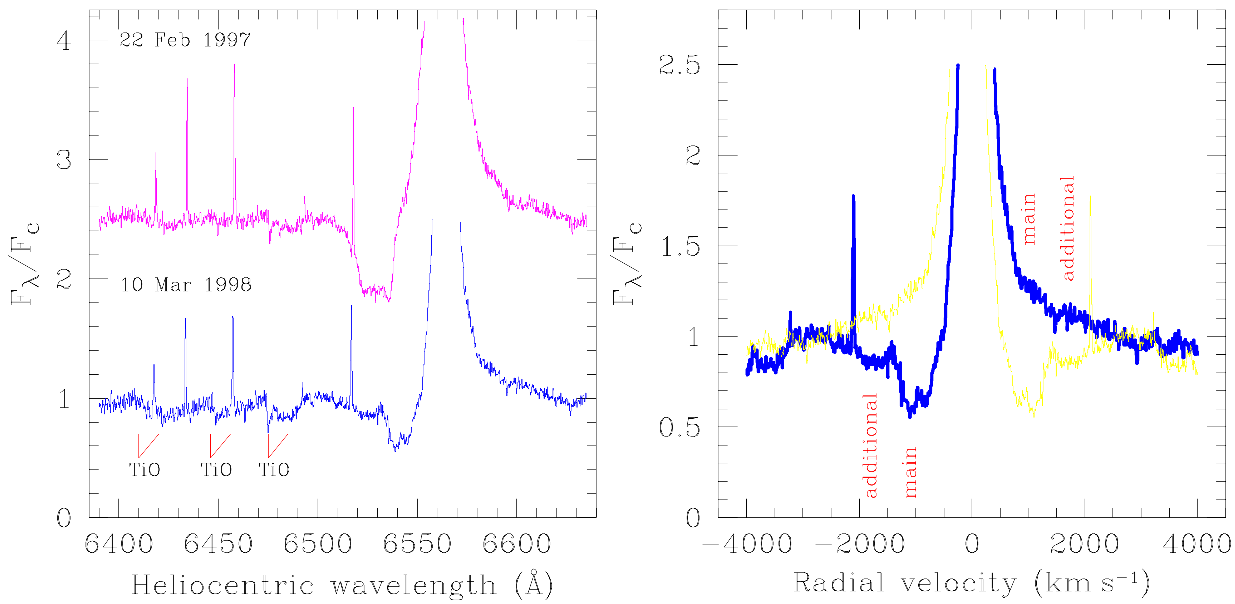

Figure 3. Left: the H_α spectral region. The H_α emission peaks are truncated and the February 1997 spectrum is shifted by 1.5 for plot clarity. Right: enlarged H_α profile of the 10 March 1998. For a better demonstration of the red-shifted jet a mirror profile with respect to central emission was plotted as a thin line

The decrease of brightness and large scatter of colour indices indicate that the pseudophotosphere around hot component has become optically thin and unstable. The A-B continuum is much weaker now or even completely absent. Probably only HII emission in the B band with a prominent Balmer jump in U are noticeable in March–April 1998. Flickering in the U band in January 1998 reached the largest amplitude ever observed, $0\overset{m}{.}7$ (Fig. 2.). From the analysis of the MWC 560 flickering given by Tomov et al. (1996, see their Fig. 6.) we conclude, that there is a possible correlation between the peak-to-valley amplitude of the MWC 560 U band flickering and the U brightness: when the star is fainter, the amplitude of flickering is greater. January results follow that rule. An amplitude of $0\overset{m}{.}7$ magnitude was observed when U brightness was about $11\overset{m}{.}1$. If this correlation is true, it means that the rapidly variable source of the flickering remains independent from the A–B pseudophotosphere brightness and varies with almost constant amplitude in flux units $\Delta F_u \approx 10^{-13}\, erg\, s^{-1}\, cm^{-2}\, \AA^{-1}$. The only visible source of the hot continuum now seems to be HII emission, so it would be identified with the flickering source.

All the photometric changes are confirmed by visual estimates made by A.J. in New Zealand with an outstanding time resolution. Only the last three photoelectric points lie $\sim 0\overset{m}{.}3$–$0\overset{m}{.}5$ below the visual light curve. We observed similar effect at the end of the previous season. The reason may be the very low position of the star above the horizon in Europe at this time, but independent UBV observations from Toruń and Belogradchik give similar results. Also, our spectral observations confirm that the significant fading of the veiling hot continuum in the optical and TiO bands of the M giant are stronger than before (Fig. 3. - left).

Generally, during 1997–98 MWC 560 was still ejecting matter in a quasi-stationary regime (see Tomov & Kolev 1997 for details). However, some changes are visible. In the last year's spectra the main blue-shifted rectangular absorption component was always visible. Occasionally an additional faster component appeared, but both were weaker than during the previous seven years (Fig. 3. - left). The typical velocity of the strongest absorption components was in the range from -1500 to $-1800\,\mathrm{km\,s^{-1}}$ till November 1997. At the end of 1997 the main absorption appeared slower (about $-1300\,\mathrm{km\,s^{-1}}$). In the spectrum from March 1998 the main, trapezoidal absorption of the H_α is significantly weaker and slower ($-1000\,\mathrm{km\,s^{-1}}$) than in 1997 and the shape of H_α looks like a P-Cyg profile. However, the emission and absorption are not physically connected. The emission probably arises close to the hot companion in a disk and/or envelope, while both absorptions originate in two separate jet-ejections. Additional faster ($\sim$2000 $\mathrm{km\,s^{-1}}$) absorption and emission (!) components are clearly visible. The red-shifted (+2000 $\mathrm{km\,s^{-1}}$) emission with the same shape and width as the blue-shifted absorption indicates the presence of a *counter*, receding jet (Fig. 3. - right). In the red wing of Hα, the emission equivalent of the main, trapezoidal absorption is probably also visible.

The photographic m_{pg} light curve from Sonneberg Sky Patrol plates which covered the period 1930–1990 (Luthardt, 1991) shows that MWC 560 spent most of that time varying between 12^{m} and 11^{m}. Only three times (1943–1954, 1958–61 and 1969–71) did the star drop to about $m_{pg} \approx 12\overset{\mathrm{m}}{.}5$ and remain relatively stable at this level for several years. This level seems to be the lowest m_{pg}/B brightness and probably indicates the non-active phase of the system, when the hot component remains inactive. Our data show that B brightness has fallen below 12^{m}, so we may expect a similar non-active phase that may last for a few years unless the behaviour of the star changes during its next possible periastron passage (in a year $\sim$ 2000). During such a quiescence phase we have a unique possibility to take a look at the close neighbourhood of a white dwarf, so additional optical, UV and X-ray observations are crucial.

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NEW RADIAL VELOCITIES AND ORBITAL SOLUTION OF THE ACTIVE BINARY STAR AR LACERTAE

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AR Lacertae (HD 210334, BD +45°3813) is a photospherically and chromospherically active eclipsing binary star (see eg. Lanza et al., 1998 and references therein) composed of a G2 IV and a K0 IV star. The primary eclipse is an occultation with a well defined totality (Wood, 1946).

Although AR Lac is a very well-studied RS CVn star, there are very few determinations of orbital and physical parameters from radial velocity measurements, because the orbital period of this system is near exactly 2 days and it is very difficult to achieve a good phase coverage during an observational run. The only published solutions are those of Harper (1933) and Sanford (1951). The latter have been revised by Popper (1980, 1990). Recently Gunn et al. (1998) determined new radial velocities but values are clustered around two specific phases.

Spectroscopic observations were obtained at the *M. G. Fracastoro* station of Catania Astrophysical Observatory in 1994, 1996 and 1997 with the 91 cm telescope, using REOSC echelle spectrograph in the cross-dispersion configuration. This mode yields a resolution of about 0.46 Å. The spectrograph is fed by the telescope through an optical fiber (UV-NIR, $200\mu m$ core diameter) and is placed in a stable position on the first floor of the telescope building. The gravity independent position and the small temperature excursions (< 1 - 2 degrees) makes the spectrograph very suitable for accurate radial velocity measurements. In 1994 the spectra were recorded on a CCD camera with a 385×576 pixel chip from E.E.V., pixel-size $22\mu m$. In the other years a CCD with 800×1152 pixels and pixel-size of $22.5\mu m$ has been used. The signal-to-noise ratio ranged from about 40 to about 150, depending on atmospheric conditions. Two and four echelle orders around the Hα region were recorded with the small and large CCD respectively.

In addition to our target, we observed some radial velocity standard stars.

The data were reduced using the ECHELLE task of IRAF [1] data reduction package. The data were flat-field corrected using a tungsten lamp. The wavelength calibration is based on a Thorium-Argon lamp. Radial velocities were obtained by cross-correlating each order of AR Lac spectra with the corresponding order of the standard star ϵ Cygni.

[1] IRAF is distributed by the National Optical Astronomy Observatory, which is operated by the Association of University for Research in Astronomy, inc. (AURA) under cooperative agreement with the National Science Foundation.

This star was selected because it has been observed throughout all the observing seasons of AR Lac and its spectrum (K0 III) is similar to one of the components of the target. Its heliocentric radial velocity is −10.6 km/s (Evans, 1967). The goodness of ϵ Cygni as a standard and the stability of experimental apparatus were tested by means of primary standard stars observed in some night leading to an accuracy of ±0.4 km/s.

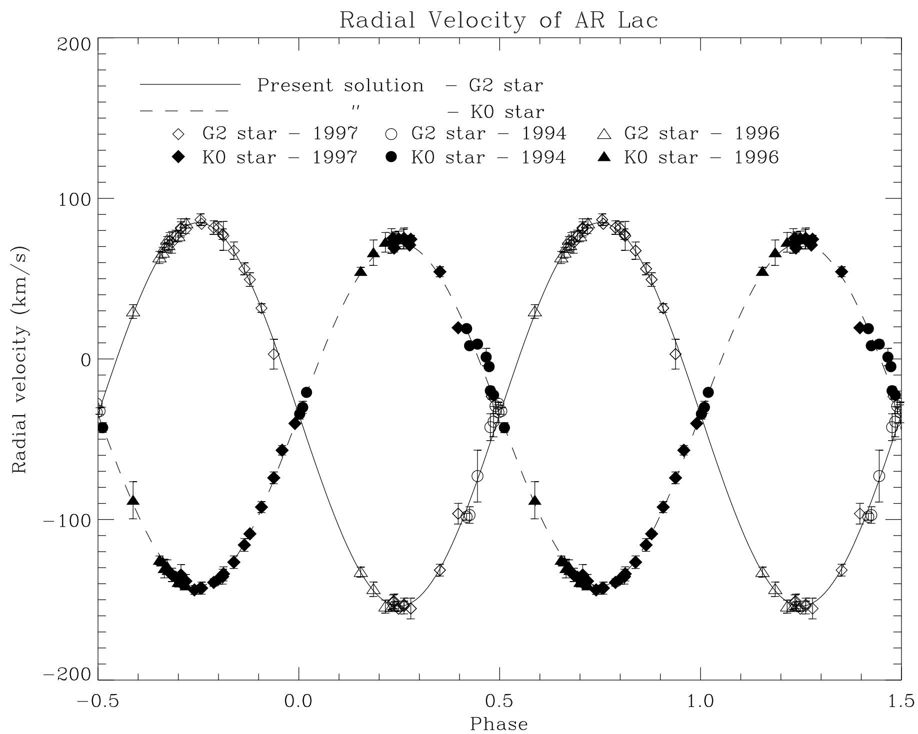

Figure 1. Radial velocity curve and best-fit solution of AR Lac

Spectral regions heavily affected by telluric lines (like the $\lambda6276$-$\lambda6315$ series of O_2) have been excluded in the cross correlation.

The evaluation of the standard errors in the radial velocities of AR Lac is a quite difficult task because of the rotationally broadened profiles of the two stars that are blended in some phases (in these cases we have used a two-gaussian fit to resolve the cross-correlation peak). The standard deviation of the values obtained from the different spectral orders has been taken as our better estimate of the errors in the RV measurements (error bars in Figure 1).

Due to the widely documented period variations (Lanza et al., 1998), we have used the ephemeris nearest to our observations to fold the data in phase.

The orbital phases for 1994 data have been reckoned by using the ephemeris:

$$HJD_{minI}{=}2447495.6369{+}1.983164{\times}\mathrm{E} \text{ (Lanza et al., 1998)}$$

For the 1996 and 1997 data the new ephemeris obtained from UBV photometry performed at Catania with the 91 cm telescope in 1995 and 1997 (Marino – unpublished observations) has been adopted:

$$HJD_{minI}{=}2450692.5174{+}1.983188{\times}\mathrm{E}$$

The observational points and best-fit sinusoidal solution (eccentricity equal to 0) are plotted in Figure 1.

In Table 1 we report the orbital and physical parameters for our and Popper's (1990) solution. The most apparent discrepancy with respect to the old solutions of Harper (1933) and Sanford (1951) is the mass-ratio which is significantly different from unity. The more evolved K0 IV star results to be more massive than the companion, consistently with a normal evolution of the two stars.

Table 1. Orbital elements of AR Lacertae

Element	Present solution	Popper (1990) solution absorption	emission
K_h	119.43 $\pm$0.49 km/s	116.5	117.4 km/s
K_c	106.73 $\pm$0.29 km/s	113.1	106.7 km/s
γ	$-$34.54 $\pm$0.5 km/s		
γ_h		$-$34.6	$-$38.5 km/s
γ_c		$-$31.7	$-$37.6 km/s
$a_h \sin i$	3.257 $\pm$0.013 $\times 10^6$ km	3.2×10^6	3.1×10^6 km
$a_c \sin i$	2.911 $\pm$0.008 $\times 10^6$ km	3.1×10^6	2.9×10^6 km
$m_h \sin^3 i$	1.122$\pm$0.008$M_\odot$	1.22	1.06 $M_\odot$
$m_c \sin^3 i$	1.255 $\pm$0.011$M_\odot$	1.26	1.12 $M_\odot$
m_h/m_c	0.894 $\pm$0.006	0.97 $\pm$0.03	0.94 $\pm$0.02

Note: h: hotter, c: cooler

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FLARE STAR SEARCH IN THE ALPHA PERSEI CLUSTER. II.

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In the frame of the flare star search programme the monitoring observations in the region of Alpha Persei cluster with the 50/70/172 cm Schmidt telescope of the National Astronomical Observatory of the Bulgarian Academy of Sciences were continued in the period August 1993 - November 1995. New 60 multiple exposure plates (emulsion ORWO ZU 21 with UG 1 filter or without filter) centred at the star BD +48°920 (R.A.(2000) = $03^h28^m02\overset{s}{.}4$, DEC.(2000) = $+49°03'54''$) were obtained. There are 6 exposures on each plate with duration of the single exposure 10 minutes. The observational log is presented in Table 1.

Table 1. Observational log for the new flare star monitoring

Year	Number of plates	Total exp. time	Number of exposures	Duration of the exposure	Band/ Filter
1993	17	17^h	102	10^m	U/UG1
1994	17	17^h	102	10^m	U/UG1
	2	2^h	12	10^m	Pg/–
1995	20	20^h	120	10^m	U/UG1
	4	4^h	24	10^m	Pg/–
Total	60	60^h	360		

The plates were checked with a CARL ZEISS blink-comparator. Two flare-ups of previously unknown flare stars were found. The designation of the new flare stars started by Semkov et al. (1993) is continued. The coordinates and photometric data in minimum and maximum brightness of the newly discovered flare stars are listed in Table 2. The new flare star referred to as FS 4 coincides with the star AP 78 in the list of members of Alpha Persei cluster from Stauffer et al. (1985).

Table 2. New flare stars in the region of Alpha Persei cluster

No.	R.A. (2000)	DEC. (2000)	Magnitude in minimum (U)	Magnitude in minimum (V)	Magnitude in minimum (V−I)	Magnitude in maximum (U)
3	$3^h15^m44\overset{s}{.}3$	$+50°28'56''$	$14\overset{m}{.}9$	$11\overset{m}{.}02$	$1\overset{m}{.}92$	$13\overset{m}{.}9$
4	$3^h29^m26\overset{s}{.}0$	$+49°20'42''$	$14\overset{m}{.}5$	$13\overset{m}{.}60$	$1\overset{m}{.}02$	$13\overset{m}{.}1$

For the identification charts (10 arcmin on a side) of the newly discovered flare stars (Figure 1) images from the Digitized Sky Survey of the Space Telescope Science Institute have been used.

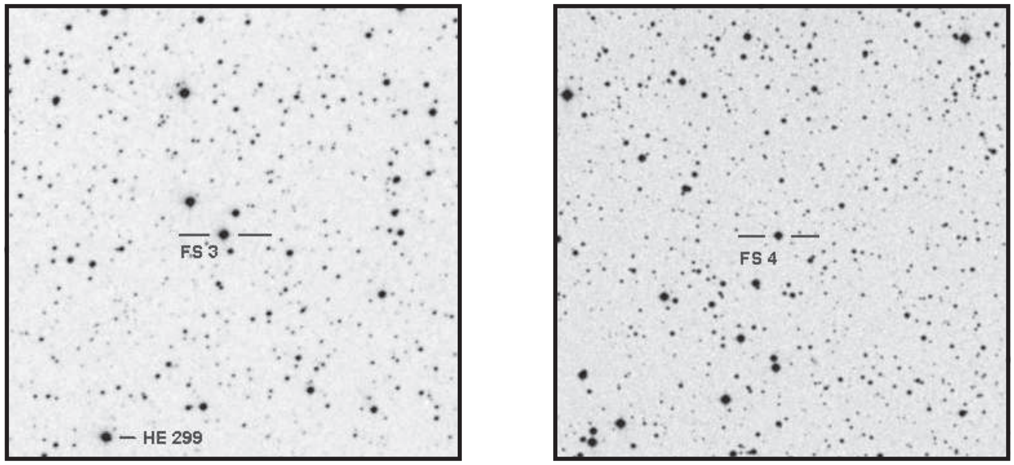

Figure 1. Identification maps of the discovered new flare stars

The (V, V−I) CCD photometry of the flare star FS 3 in minimum was made on August 7, 1994 with an ST6 CCD camera attached to the 2 m RCC telescope of the National Astronomical Observatory of the Bulgarian Academy of Sciences. All exposures were reduced in the same manner as described in Georgiev et al. (1994). The photoelectric photometry of the star FS 4=AP 78 in quiet state is given according to Stauffer et al. (1985). The photographic photometry in U light in quiet state (Table 2) and during the flare-up (Table 3) is made with an iris-photometer Ascoris using the existing standards of Mitchell (1960) in the region. The mean square error of the calibration curves is $0\overset{m}{.}2$ due to the quality of the monitoring photographic plates.

From the positions of the new flare stars on the V/V−I colour-magnitude diagram of Prosser (1994) it is obvious that FS 3 has a photometric behaviour which is unacceptable for cluster membership. The nearest known member of the cluster is the star HE 299 from the first complete proper motion survey of the region up to $12\overset{m}{.}0$ (pg) by Heckmann et al. (1956). On the positional basis the star might be associated with the red star ROSS 347=LTT 11060 from the Luyten Catalogue of stars with proper motions larger than $0\overset{''}{.}2$/yr and First Supplement. Such bright star as FS 3 showing flare-ups and which is not member of the cluster might be a representative of the foreground field UV Cet stars.

The star FS 4 lies on the same V/V−I colour-magnitude diagram quite well on the cluster sequence as can be expected from its cluster membership derived already by Stauffer et al. (1985).

Table 3. Photographic photometry of the newly discovered flare stars during their flare-ups

FS No.	Plate. No.	Exposure No.	J.D.	Magnitude mag(U)
3	6972	1	2449340.4646	14.7
3	6972	2	.4719	13.9
3	6972	3	.4792	14.1
3	6972	4	.4865	14.5
3	6972	5	.4938	14.8
3	6972	6	.5010	14.9
4	7133	1	2449576.5208	14.5
4	7133	2	.5281	13.3
4	7133	3	.5354	13.1
4	7133	4	.5427	13.5
4	7133	5	.5500	13.8
4	7133	6	.5573	14.2

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